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Systems

OS/VS Mass Storage System (MSS) Planning Guide

IBM®

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Third Edition (July 1977)

This is a reprint of GC35-0011-1 incorporating changes released in the following Technical Newsletters:

GN35-0032 (dated June 1, 1976)
GN35-0047 (dated September 27, 1976)
GN35-0034 (dated October 1, 1976)
GN35-0048 (dated December 20, 1976)
GN35-0051 (dated February 14, 1977)

This edition applies to Release 6 of OS/VS1 and Release 3.7 of OS/VS2 that support the Mass Storage System and to all subsequent releases until otherwise indicated in new editions or Technical Newsletters. The information contained in this edition about the MSS Enhancements is for planning purposes only until the MSS Enhancements are available.

The information contained in this publication is subject to significant change. Any such changes will be published in new editions or technical newsletters. Before using this publication in connection with the operation of IBM systems, consult the *IBM System/370 Bibliography*, GC20-0001, for the editions that are applicable and current.

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A form for reader's comments is at the back of this publication. Address any additional comments to Information Planning and Editing, Dept. 21E, P. O. Box 1900, Boulder, Colorado 80302.

About This Publication

This manual is for data processing managers, system programmers, and application programmers. It contains general information concerning the physical characteristics of the IBM 3850 Mass Storage System and describes in general the programming support provided by OS/VS1 and OS/VS2.

This publication is for planning purposes only. The functions and capabilities described reflect the information that is currently available.

Major Divisions of the Publication

This publication contains the following sections:

- "Introduction," which describes the Mass Storage System hardware and the concepts of virtual DASD, staging, and destaging.
- "New Programs to Support the Mass Storage System," which describes the new programming support for the Mass Storage System—Mass Storage System Communicator including Mass Storage Volume Control functions, Mass Storage Control Table Create, new Access Method Services commands, and ERP support.
- "Changes to Existing Programs to Support the Mass Storage System," which describes the changes to existing programs (such as JCL, Utilities, and access methods) to support the Mass Storage System.
- "How Do Existing Jobs Change?," which describes the changes to the jobs of the system programmer, system operator, and application programmer.
- "What New Responsibilities Are Introduced?," which describes the job of the space manager.
- "Glossary," which is a list of terms used in this publication.

Required Publication

- *Introduction to the IBM 3850 Mass Storage System (MSS),* GA32-0028, which provides an overview of the Mass Storage System.

Related Publications

- *OS/VS Mass Storage Control Table Create,* GC35-0013, which describes the Mass Storage Control Table Create program.
- *OS/VS Mass Storage System (MSS) Services: General Information,* GC35-0016, which describes in general how to use the Mass Storage System Services commands.
- *OS/VS Mass Storage System (MSS) Services: Reference Information,* GC35-0017, which describes the Mass Storage System Services commands. You can order this and the above publication by specifying GBOF-3579.
- *OS/VS Message Library: Mass Storage System (MSS) Messages,* GC38-1000, which describes the messages issued by the Mass Storage System.
- *OS/VS Message Library: VS1 System Messages,* GC38-1001, which describes the VS1 system messages.

- *OS/VS Message Library: VS2 System Messages,* GC38-1002, which describes the VS2 system messages.
- *Operator's Library: IBM 3850 Mass Storage System (MSS) Under OS/VS,* GC35-0014, which describes the operator commands for the Mass Storage System.
- *Mass Storage System (MSS) Principles of Operation,* GA32-0029, which describes the Least Recently Used (LRU) algorithm, sense data, Subsystem Identification (SSID), and Virtual Unit Addresses (VUA).
- *IBM 3850 Mass Storage System (MSS) Installation Guide,* GA32-0030, which helps you define your logical configuration and prepare your conversion and recovery plans in preparation for your Mass Storage System.
- *OS/VS Mass Storage Control Trace Reports Logic,* SY35-0014, which describes the logic of the Trace Reports program.
- *OS/VS Mass Storage System Table Create Logic,* SY35-0016, which describes the logic of the Mass Storage Control Table Create program.
- *OS/VS Mass Storage System (MSS) Services Logic,* SY35-0015, which describes the logic of the Mass Storage System Services commands.
- *OS/VS1* Mass Storage System Communicator *(MSSC) Logic,* SY35-0012, which describes the logic of the OS/VS1 Mass Storage System Communicator.
- *OS/VS2 MVS Mass Storage System Communicator (MSSC) Logic,* SY35-0013, which describes the logic of the OS/VS2 MVS Mass Storage System Communicator.
- *OS/VS2 System Programming Library: SYS1.LOGREC Error Recording,* GC28-0677, which describes how to use the SYS1.LOGREC data set, the System Data Anaylzer (SDA) program, and the Data Cartridges Statistics Report for a VS2 system.
- *OS/VS1 System Programming Library: SYS1.LOGREC Error Recording,* GC28-0668, which describes how to use the SYS1.LOGREC data set, the System Data Analyzer (SDA) program, and the Data Cartridge Statistics Report for a VS1 system.
- *OS/VS2 TSO Command Language Reference,* GC28-0646, which describes the TSO command language.
- *OS/VS2 TSO Terminal Users Guide,* SC28-0644, which describes how to use the TSO terminal.
- *OS/VS1 Job Control Language Services,* GC24-5100, which describes how to use job control language.
- *OS/VS2 Job Control Language,* GC28-0692, which describes how to use job control language.
- *OS/VS Utilities,* GC35-0005, which describes the utility programs available for use with the non-VSAM data sets on VS1 and VS2 systems.
- *OS/VS Utilities Logic,* SY35-0005, which describes how the OS/VS utility programs work.
- *OS/VS2 MVS JES3 Mass Storage System Selectable Unit System Information,* GC23-0018, which describes the JES3 support for the Mass Storage System.

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Major Technical Changes

The MSS Enhancement information has been included in this book for planning purposes only until the MSS Enhancements are available. The MSS Enhancement include the following information:

- General information on the new recovery commands COPYT, DUMPMSS, NULLIFYC, and SWAPT is provided in this book.
- General information on direct access to the Mass Storage Control tables is provided in this book.
- Two new commands and two new options for an existing command for the space manager. The new commands are LISTDSET and SCRDSET. The new options for the LISTMSVI command are ALLCARTRIDGES and CARTRIDGES.
- Three new commands for recovery. The three new commands are AUDITMSS, CHECKMSS, and COMPARET.
- A new operator command, DISPLAY 3850.

Minor technical changes have been made throughout the book. These technical changes are indicated by a vertical line to the left of the change.

Introduction

At this time, you should be familiar with the information contained in the book *Introduction to the IBM 3850 Mass Storage System (MSS).* Some of the information presented in that book is stated again in this book for several reasons: (1) The Mass Storage System is complex, (2) the restated information in this book is from a different view point, and (3) it is necessary to restate some information in order to explain the conceptual parts of this book.

The 3850 Mass Storage System (MSS) is a hierarchical system that makes up to 472 billion (472×10^9) bytes of data available under system control. 472 billion (472×10^9) bytes of data is equivalent to 4720 3336 Model 1 disk packs or approximately 8000 full reels of magnetic tape written at a density of 1600 bits per inch. Data at the lowest level of the hierarchy is contained on magnetic media in data cartridges. This data cannot be accessed directly by programs running in the CPU. For the operating system to access the data, the data must be moved to the next level of the hierarchy. That level consists of 3330 Disk Storage devices. The movement of data from data cartridges to 3330 Disk Storage devices is transparent to programs running in the CPU. From the 3330 Disk Storage devices, the data is transferred in and out of the CPU just as 3330 Disk Storage data is transferred without the Mass Storage System. All of the data and its movements from the data cartridge to the CPU is under the control of the Mass Storage System.

What is the Principal Concept of the Mass Storage System?

The concept of the Mass Storage System is to have available for use up to 472 billion (472×10^9) bytes of data without human intervention. To have this much data immediately available with the present computer systems would require many more DASD devices or tape drives than are economically feasible to operate and maintain. Even if you could operate and maintain enough devices to have 472 billion bytes of data on line, the operating system would only use small pieces of that total amount of data. Most of the 472 billion bytes of data would not be referenced at all.

The Mass Storage System overcomes this by putting on DASD only those cylinders of a volume that are requested by the program asking for data. The Mass Storage System places the required data of different volumes on the same DASD drive. To the operating system, the data appears as separate complete volumes on separate DASD drives. The concept of allowing one DASD drive to appear as many drives to the operating system is called virtual DASD.

Virtual DASD

The Mass Storage System provides virtual DASD. To explain the concept of virtual DASD, let's compare a tape system with a system that contains the Mass Storage System. Of course, this same type of comparison works for a DASD system of today.

For the comparison, let's assume the operating system has asked for a volume to be mounted. In a computing system that does not have the Mass Storage System, the system continues with the work it has while the job that needs the tape volume waits. The system librarian finds the needed reel and logs it out. The system operator mounts the tape reel containing the wanted data and the operating system is notified that the volume is mounted and ready. The operating system reads the tape label and verifies it. The tape is then positioned to access the needed data, and, data is transferred in and out of the CPU as the program uses it.

If the same type of request was issued for a volume that is in the Mass Storage System, the Mass Storage System locates the needed volume, mounts it, and notifies the operating system that the volume is available. All this activity–locating, mounting, and notification–is done without human intervention. Because there is no human intervention and because the Mass Storage System knows exactly where all the volumes it contains are located, there is less chance of mounting the wrong volume and usually less time delay between the need for the volume and the availability of the volume.

The Mass Storage System is a hierarchical system in which data is available at one of three levels. When the Mass Storage System is attached to a CPU, the data is either in the 3851 Mass Storage Facility (the 3851 Mass Storage Facility is explained in the section "The Mass Storage Facility"), on DASD devices that are under the control of the Mass Storage System, or in the CPU. The Mass Storage System must move the data from its lowest level of storage, the data cartridges in the Mass Storage Facility, to the next level of storage, the DASD devices, before the operating system can access the data. The movement of data from the Mass Storage Facility to the DASD devices is called *staging*. When the operating system is finished with the data, data that has been created or modified is moved back into the Mass Storage Facility. The movement of data from the DASD devices to the Mass Storage Facility is called *destaging*.

The Mass Storage System stages only the cylinders of a volume that contain the data needed by the operating system. The Mass Storage System can place the cylinders of different volumes on the same DASD drive while maintaining the illusion of having them on separate drives. This is the *virtual* DASD concept. As far as the operating system is concerned, all the data it uses represents real volumes on real DASD. But in actuality, the addresses used by the operating system to access the data may all be on the same DASD drive. It is the job of the Mass Storage System to translate the unit addresses and cylinders used by the operating system to the actual unit addresses of and cylinders on a virtual DASD. This allows you to have much more data available for processing than you actually have DASD drives. When a DASD drive is used to store cylinders from many different volumes of data, the DASD drive is called a *staging drive.* The cylinders of volumes staged to a staging drive are called *virtual volumes.* The virtual volumes appear as real volumes to the operating system. The size of a virtual volume varies from 1 to 404 cylinders depending upon the amount of data asked for by the operating system.

How Does the Mass Storage System Operate?

Data is stored in the Mass Storage System on a magnetic media in *data cartridges.* A data cartridge is illustrated in Figure 1. In the Mass Storage System, data cartridges that contain useful data are always handled in pairs. The two data cartridges can contain the same amount of data as one 3336 Model 1 disk pack and are called a *mass storage volume.* The mass storage volumes are stored in a part of the Mass Storage System called the *Mass Storage Facility.* Mass storage volumes that contain data with similar characteristics can be grouped. These groups are called *mass storage volume groups.*

To understand how the Mass Storage System operates, it is necessary to understand each of its units.

Throughout this book, diagrams of units of the Mass Storage System are used. The lines connecting the units in the diagrams represent the cabling of the Mass Storage System. The way the units are connected is called the Mass Storage System configuration, and it is an important consideration for the efficient operation of the Mass Storage System. You should make no assumptions that the diagrams represent either an ideal selection of hardware or the ideal configuration of the hardware selected. The hardware and the configurations selected are used just for examples in this book. Neither the hardware nor the configuration represents even a minimum system.

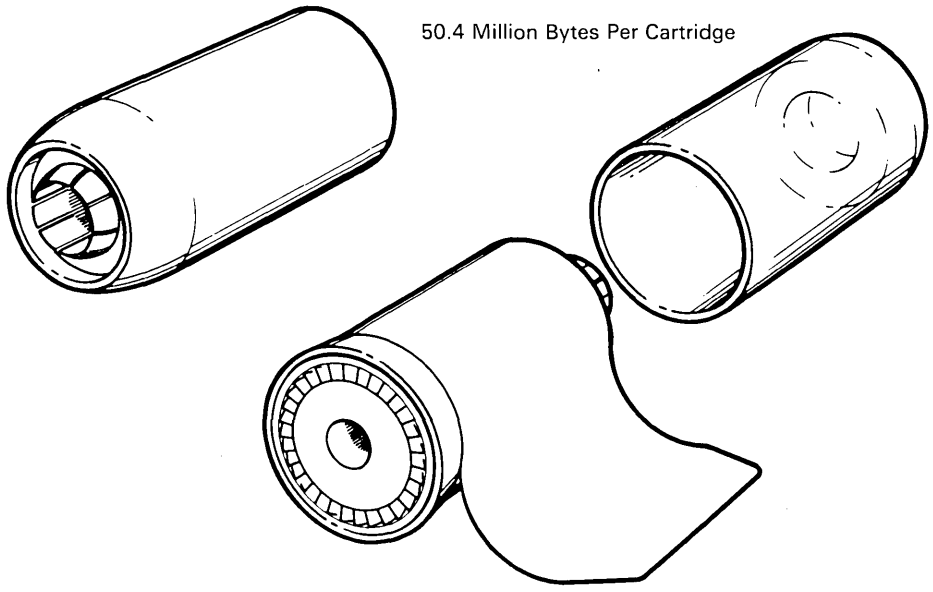


Figure 1. Data Cartridge

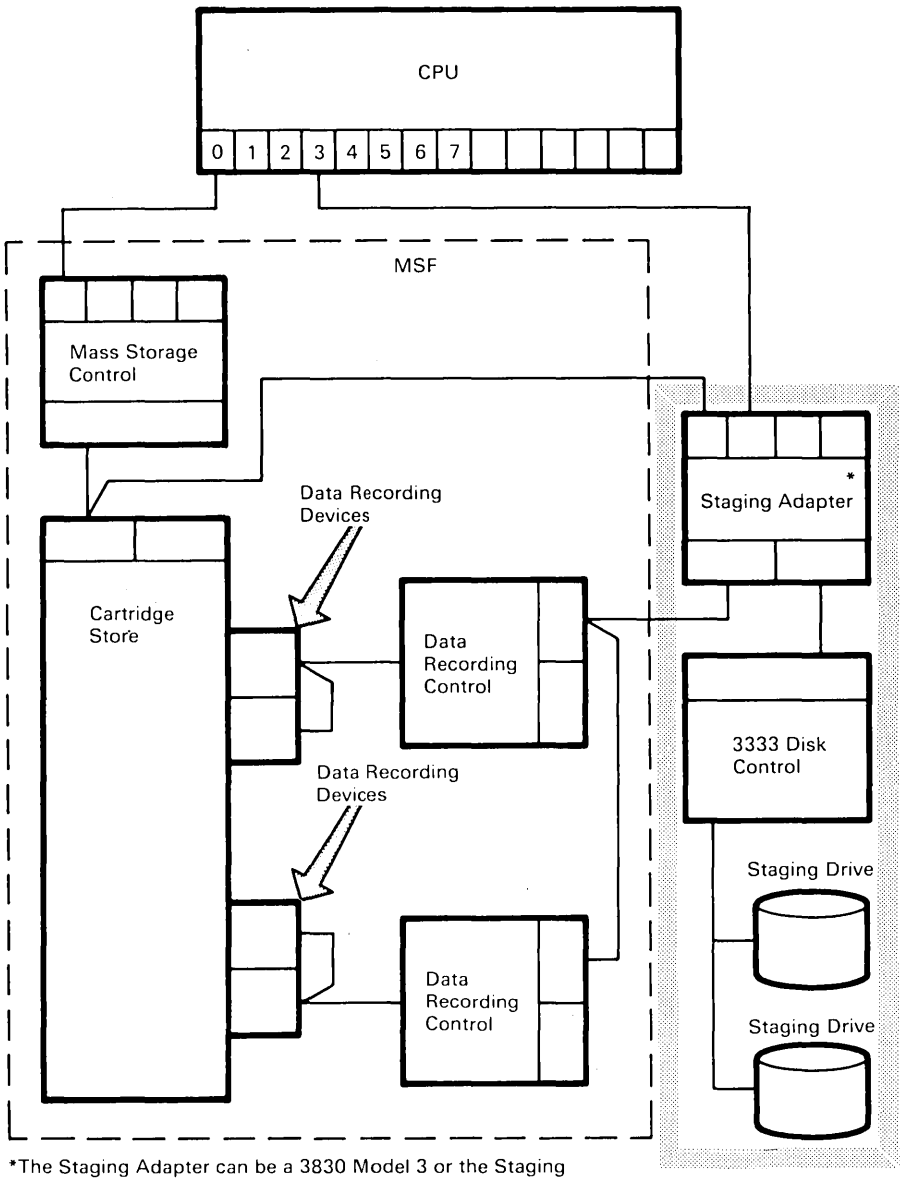
The Staging Adapter

"Staging Adapter," as used in this book, refers to either a 3830 Model 3 or the Integrated Storage Control feature with the Staging Adapter. The Staging Adapter controls the flow of data to and from the DASD devices that are attached to the Mass Storage System. The Staging Adapter also maintains tables showing the locations of all virtual volumes on staging drives under its control. The translation from the virtual unit and cylinder addresses presented by the operating system, to the physical unit and cylinder addresses of a particular staging drive is performed by the Staging Adapter. The data on the DASD devices can come from the Mass Storage Facility, when data is being staged to a staging drive, or from the operating system, when the operating system is using the virtual volumes that are on the staging drives. In the case when the operating system is using the virtual volumes on the staging drives, the Staging Adapter handles the data transfers directly to the operating system.

Figure 2 is a Mass Storage System diagram highlighting the Staging Adapter, the 3333 Disk Control, and 2 staging drives. The 3333 Disk Control is the control that is in use today and it performs the same functions that it would perform without the Mass Storage System. The staging drives attached to the 3333 Disk Control are the same 3330 Disk Storage devices that are normally used. Throughout this book, the 3330 Disk Storage and Control are described as two separate devices. This is because a particular description can be about the Disk Storage or the Disk Control but not both.

All Staging Adapters are connected to the Mass Storage Control. At least one of the connections of the Staging Adapter must attach to a CPU. More than one CPU can attach to the same Staging Adapter.

The first connection at the bottom of the Staging Adapter must attach to a data recording control within the Mass Storage Facility. The second connection attaches to a 3333 Disk Control. The Disk Control in turn connects to the staging drives in the same manner as drives are connected without the Mass Storage System.



*The Staging Adapter can be a 3830 Model 3 or the Staging Adapter feature on the Integrated Storage Control feature.

Figure 2. MSS Diagram Highlighting the Staging Adapter, Disk Control, and Staging Drives

The Mass Storage Facility

The 3851 Mass Storage Facility (MSF) consists of three units that work together to provide the advantages of the Mass Storage System. The components are: (1) the Mass Storage Control, (2) the data recording device and data recording controls, and (3) the cartridge store. Figure 3 is an illustration of the Mass Storage Facility.

Mass Storage Facility Status Indicators. The Mass Storage Facility status indicators show you when work is being done. The SYSTEM lights indicate that the subsystem has work being done or queued to be done. The WAIT light indicates that the subsystem is waiting for work to do.

IML Switch. The IML switch enables you to Initial Microprogram Load the Mass Storage Control for startup or restart. There are two switches, one for each Mass Storage Control. If there is only one Mass Storage Control one of the switches doesn't work.

CLEAR Switch. The CLEAR switch prepares the Mass Storage Control for a dump and/or re-IPL. It will break the Mass Storage Control out of a loop or hang, terminate jobs using the Mass Storage Control, and save information to allow a meaningful dump to be taken from the host.

For a more detailed description of the Mass Storage Facility Status Indicators, the IML Switch, and the CLEAR Switch see the publication *IBM 3850 Mass Storage System (MSS) Principles of Operation.*

Mass Storage Control

The Mass Storage Control (MSC) provides the intelligence to manage the Mass Storage System. There is one and only one Mass Storage Control in control of the Mass Storage System at any one time. The operating system communicates with the Mass Storage Control through a standard System 370 Byte or Block Multiplexer Channel Interface. Through this interface, the operating system sends its requests to the Mass Storage Control and the Mass Storage Control controls the execution of the request. The Mass Storage Control also maintains and uses tables to control the activity of the Mass Storage System. The Mass Storage Control tables are described in the section "Mass Storage Control Tables."

Some of the functions of the Mass Storage Control are:

- Keeping track of the physical configuration of the Mass Storage System
- Keeping track of the location, attributes, and status of all mass storage volumes
- Scheduling work for cartridge store components
- Communicating with the Staging Adapters
- Communicating with the operating systems

Figure 3 also shows the location of the Mass Storage Control within the Mass Storage Facility.

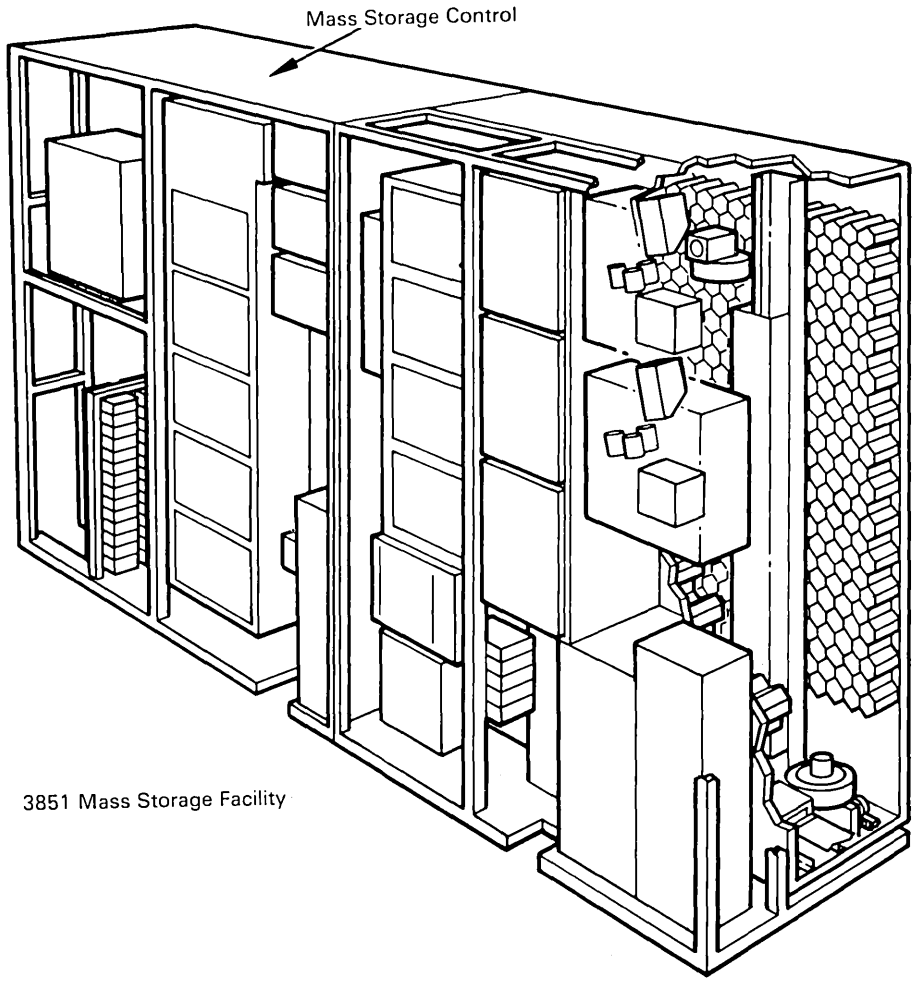
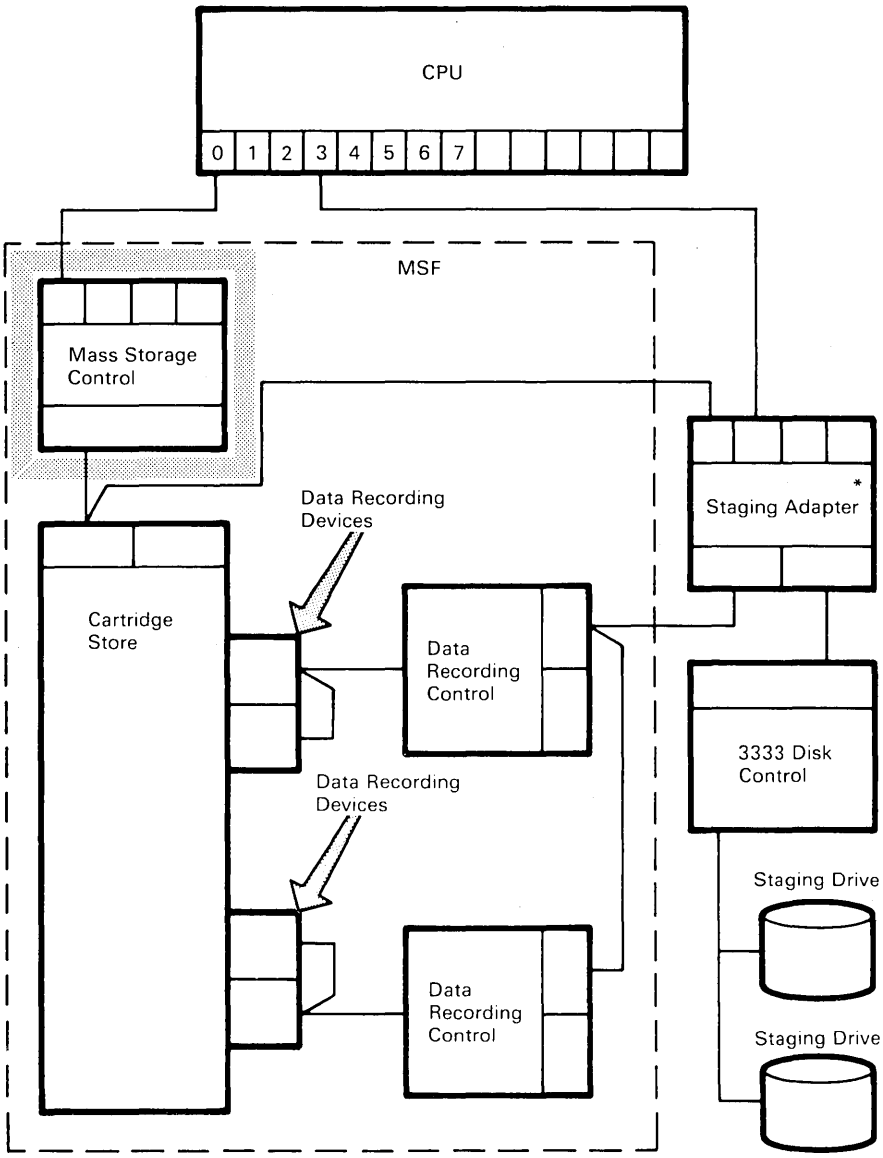


Figure 3. Mass Storage Facility

Figure 4 is a Mass Storage System diagram highlighting the Mass Storage Control. If more than one CPU is attached to the Mass Storage Control and Staging Adapters, one of the CPUs is regarded as the primary CPU. All CPUs can send orders to the Mass Storage Control and receive data from and send data to the Staging Adapter, but only the primary CPU receives the non-task oriented messages of the Mass Storage Control.

The Mass Storage Control is connected to the accessor control and to the Staging Adapter.



*The Staging Adapter can be a 3830 Model 3 or the Staging Adapter feature on the Integrated Storage Control feature.

Figure 4. MSS Diagram Highlighting the Mass Storage Control

Data Recording Control and Data Recording Device

The data recording devices are grouped in pairs and each pair is under the control of a data recording control. Figure 5 is an illustration of the Mass Storage Facility showing the location of the data recording devices and the data recording control. Figure 6 is a Mass Storage System diagram highlighting the data recording controls and the data recording devices. Data recording devices are physically grouped in pairs. In this diagram, a physical pair of data recording devices connects to a data recording control. The data recording device, under the direction of the data recording control, reads from or writes on the magnetic media in the data cartridges.

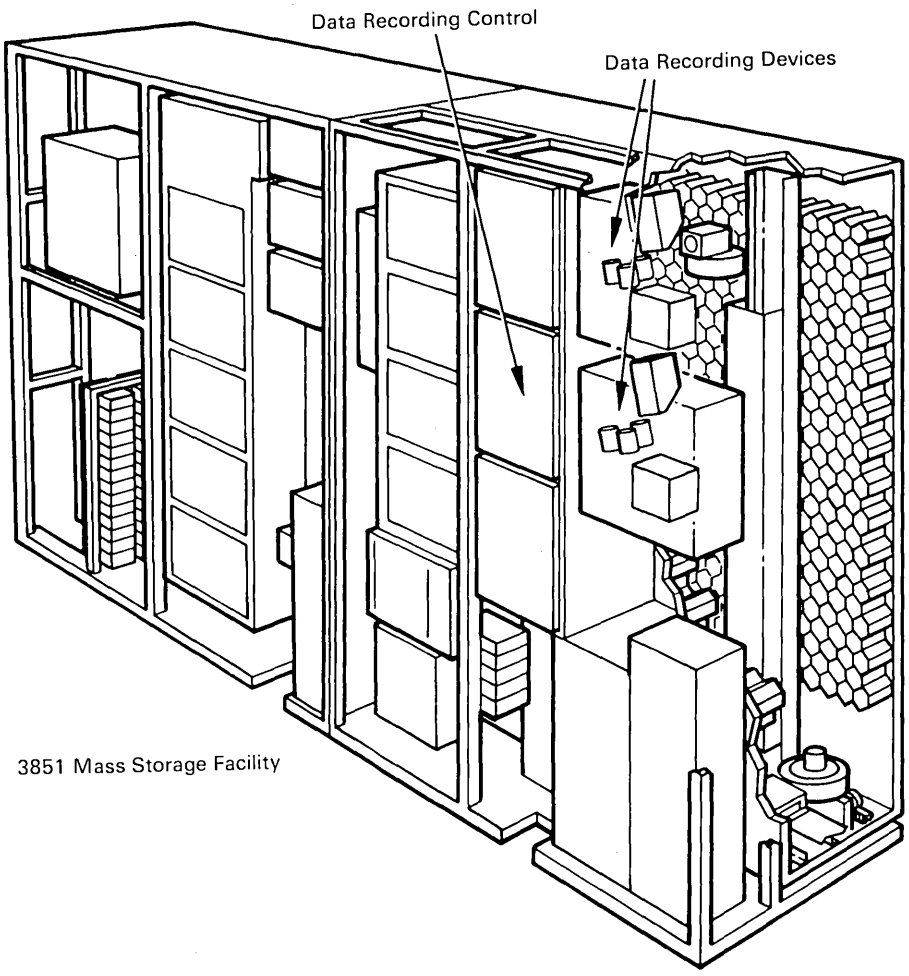
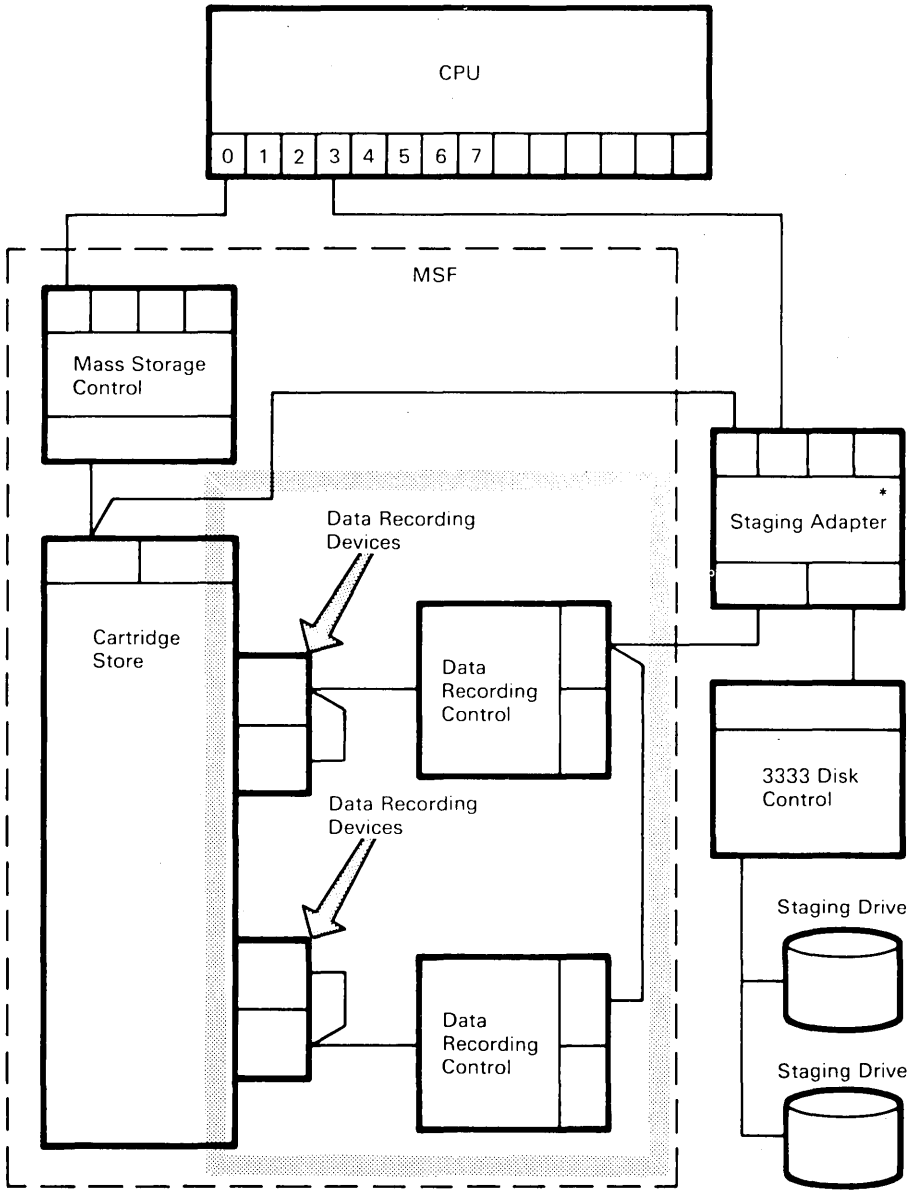


Figure 5. Data Recording Control and Devices



*The Staging Adapter can be a 3830 Model 3 or the Staging Adapter feature on the Integrated Storage Control feature.

Figure 6. MSS Diagram Highlighting the Data Recording Control and Devices

Cartridge Store

The cartridge store contains the cells, accessors and accessor controls, and the cartridge access station. When data cartridges are not in the data recording devices or being moved by the accessor, they are in the cells of the cartridge store. Each data cartridge has a cell location that is known to the Mass Storage System by XYZ coordinates.

In any size cartridge store, there are nine cells that cannot be used for user data. These cells are set aside for use by the Customer Engineer and the Mass Storage Facility.

Figures 7 and 8 illustrate the cartridge store.

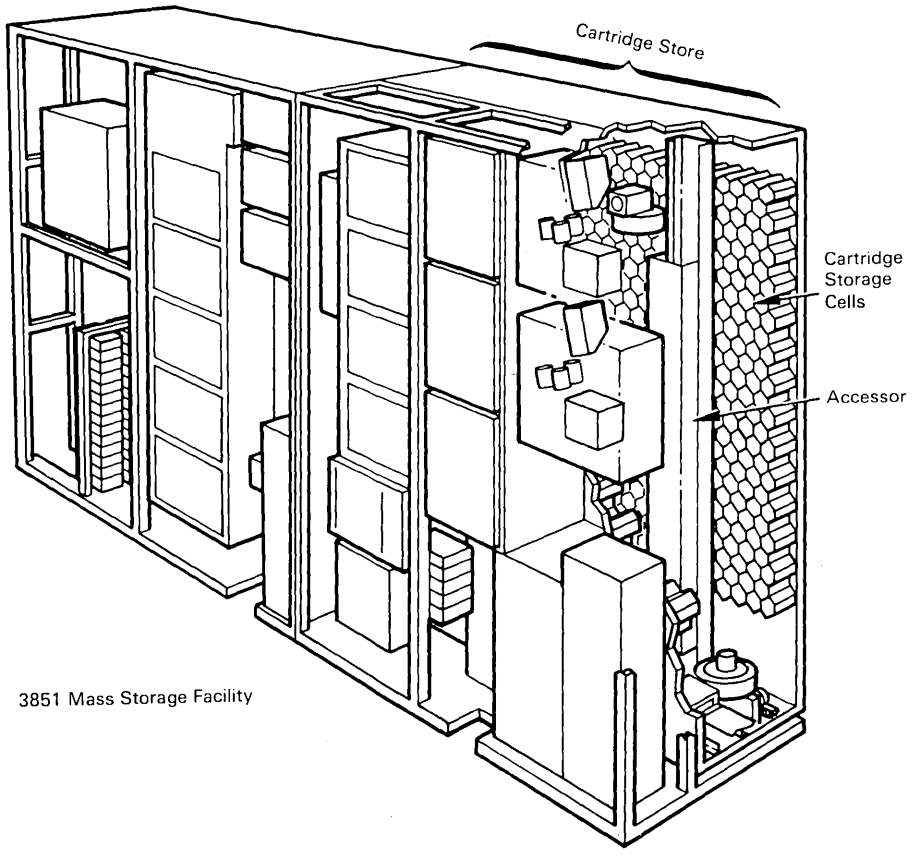
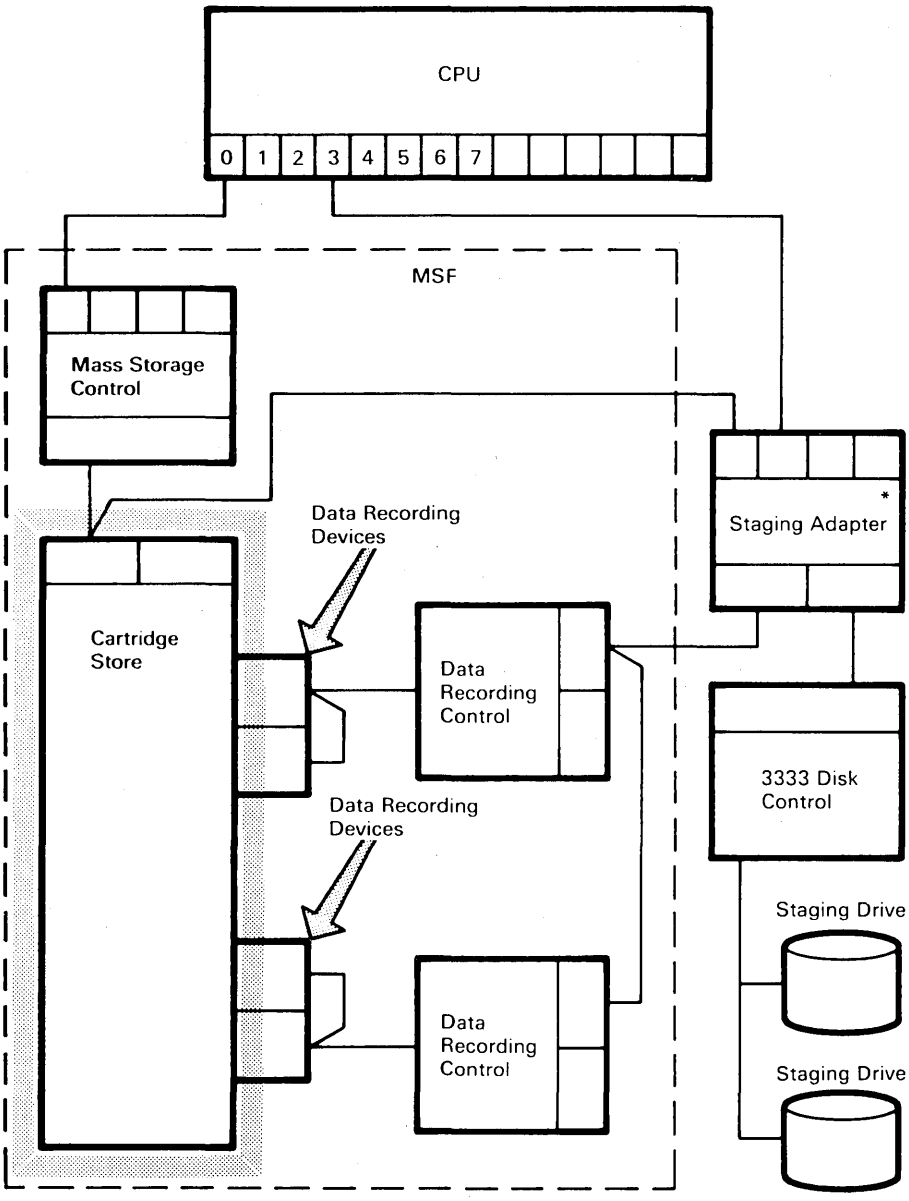


Figure 7. Cartridge Store

The accessor and accessor controls move data cartridges between cell locations, data recording devices, and the cartridge access station. When a data cartridge must be moved, the accessor control moves the accessor from its current location to the location of the data cartridge. The accessor retrieves the data cartridge and delivers it to the location specified by the accessor control.

The cartridge access station is an opening on the front of the Mass Storage Facility to permit manual entry and removal of data cartridges.



*The Staging Adapter can be a 3830 Model 3 or the Staging Adapter feature on the Integrated Storage Control feature.

Figure 8. MSS Diagram Highlighting the Cartridge Store

Mass Storage System Drives

There are three classifications of drives that can be attached to the 3333 Disk Control. Each of these classifications results in different handling of the drive by the Mass Storage System, requires different definition when generating the system, and requires different system operator procedures and rules when the drives are being manipulated during Mass Storage System operation.

The three classifications of drives are:

- Real
- Staging
- Convertible (from real to staging or staging to real)

In the Mass Storage System, there are two types of packs that must be initialized: real packs and staging packs. Convertible drive packs should be initialized as staging packs. The IEHDASDR utility initializes real packs. The release of IEHDASDR that supports staging drives is used to initialize staging packs.

Real Drives

The drives that are classified as real are used just as DASD devices are used without the Mass Storage System. The Staging Adapter handles the real drives just as a 3830 Model 2 Storage Control does under normal conditions. Even though the real drive is part of the Mass Storage System, no data is staged to it. There must be a real path between the operating system and the drive and there must be a Unit Control Block describing a real drive.

Staging Drives

The drives that are classified as staging drives can be used only for staging. The allocation of space on a staging drive is controlled by the Mass Storage Control. There is no real path between a staging drive and the operating system. A request for data on a staging drive is intercepted by the Staging Adapter and translated to access the correct cylinder and track on which the data is staged. The system operator can vary a staging drive on or offline to the Mass Storage Control by specifying the correct Mass Storage System Identification for the drive.

Staging drives are arranged into groups called *staging drive groups.* The Mass Storage Control considers the space available in an entire staging drive group instead of just the space available on a single staging drive. That is, if you wanted to stage data and the Mass Storage System was operating at high activity, your data may not all be placed on the same staging drive. It can be placed on several different staging drives that together contain enough space to hold your data and are all in the same staging drive group.

There is a status called *neutral* that can affect staging drives and convertible drives that are varied on as staging drives. The neutral status usually occurs because of an error. Both the staging pack and the drive plug must be exchanged with another drive under the same 3333 Disk Control in the same staging drive group or the staging drive pack, but not the plug, must be moved to another drive in the same staging drive group under a different 3333 Disk Control before the data that was on the neutral drive can be accessed.

Convertible Drives

Drives that are classified as convertible can either be used as staging drives or as real drives. The classification of the drive can be changed while the Mass Storage System is operating. If the drive is to be made real, the real path between the drive and the operating system must be available. When the drive is a staging drive, this real path must not be available.

Now that the basic function of the units of the Mass Storage System have been described, let's see how the units fit together to handle data.

How Does the Mass Storage System Handle My Data?

When an existing data set is requested, the operating system allocates a virtual device address. The Mass Storage System locates the data cartridges that make up the mass storage volume, allocates a page (8 cylinders) of staging space on a staging drive, and stages up cylinder zero of the requested mass storage volume. When the volume verification routine of the operating system goes to read the volume serial number, the request goes through the Staging Adapter, which translates the virtual device address and virtual volume location of cylinder zero, track zero, record three (X'00003') to the staging drive and cylinder address on the staging drive where that record has been staged. To the operating system, everything appears as unsual.

When a request is made for a new non-VSAM data set on a specific mass storage volume, the process is the same, except that after volume verification, the Direct Access Device Space Management (DADSM) routines read the Volume Table of Contents (VTOC) to locate space for the new data set. If the Volume Table of Contents is not on cylinder zero, the Staging Adapter recognizes that the VTOC has not been staged. The Mass Storage Control and Staging Adapter work together to find another page of staging space if required, locate the data cartridge containing the VTOC, and stage the VTOC. Then the request is satisfied. The appearance to the operating system is that the 'seek' channel command took longer than normal to complete.

When a request for a new non-specific non-VSAM data set is made, but no volume serial number is specified, (you can specify a mass storage volume group name on your DD card), volume selection is assisted by the Mass Storage Volume Control functions of the Mass Storage System Communicator. The Mass Storage Volume Control functions and the Mass Storage System Communicator are described in the section "Mass Storage System Communicator."

Because non-specific requests could cause data sets to be spread over many mass storage volumes, Mass Storage Volume Control functions provide a mechanism for grouping small numbers of volumes, thus minimizing the spreading effect. The criteria for grouping mass storage volumes is completely at your discretion. Aside from the assistance from the Mass Storage Volume Control functions, this allocation request looks just like the previous case.

At this point in time, the virtual volumes have been mounted on the staging drives allocated to them. Sometime during the execution of your program, the program issues an OPEN to these data sets. At that time, the Mass Storage Control is requested to allocate an appropriate number of pages on a staging drive to hold the data. OPEN does not wait for completion of data set staging before returning to your program.

Your program eventually issues an I/O request, a GET for example, to the open data set on a virtual volume. The request goes through the access method modules it has always gone through. These modules convert the request into terms the operating system uses—control blocks and channel commands—as before. A request for a record identifies a unit address and the cylinder, track, and record number of that record. The request goes through I/O Supervisor exactly as before. When the channel program reaches the Staging Adapter, this device translates the virtual unit address to the real address of the staging unit that contains the requested page, and translates the cylinder number of the virtual unit to the cylinder number of the staging drive containing the data. Since data is staged and destaged in increments of cylinders, the track number and record number do not need to be translated. The I/O operation is completed in the usual manner.

If the table-lookup of the Staging Adapter is unsuccessful—in particular, if the cylinder requested was not found in the tables—a *cylinder fault occurs.* A cylinder fault may occur, for example, because the data set was not completely staged before the request for this record was made. The Staging Adapter notifies the Mass Storage Control, and works with the Mass Storage Control, to locate and stage the desired cylinder. If a cylinder fault occurs while the data set is being staged, the cylinder fault is serviced after the staging operation is complete. The I/O operation is then completed normally. The appearance to the operating system is that, once again, the 'seek' command took longer than normal to complete.

The Mass Storage Control and the Staging Adapter maintain tables that reflect the status of all Mass Storage System activity. One of these tables maps virtual volume pages (8 cylinders) to staging drive pages, and the entries in this table reflect, for each cylinder in a given page, whether some record on that cylinder has been referenced or changed. Whenever a cylinder is referenced, the table entry describing the page containing that cylinder is given a timestamp. As the Mass Storage System goes about its work, a shortage of staging space can be encountered. When the amount of allocatable staging space for any staging drive group reaches a high threshold value, which you have specified through a new command, the Mass Storage Control must free up enough of the occupied space in this staging drive group to reduce the number of active pages to a low threshold that you have specified. The high and low values and the new command are described in the section "The TUNE Command."

To free up space, the timestamp associated with each page is examined. The least recently used pages are selected, until enough pages have been selected to bring the number of active pages to the low threshold or until there are no further pages old enough to be considered for selection. You define how many timestamps ago constitutes "old enough." The selection is done through the use of the Least Recently Used algorithm. For all pages thus selected, data on cylinders that have been changed is destaged and the space is made available for subsequent allocations. For volume requests for space for new, non-specific, non-VSAM data sets, the allocation to mounted volumes support attempts to satisfy the space request on a volume that is mounted. A mounted volume can continue to be selected to satisfy such requests as long as enough free space exists on the volume. This support must be initialized with the group management commands. The group management commands are described in detail in the section "New Programs to Support the Mass Storage System". The Mass Storage Control keeps track of what data was on each page until the page must be reallocated. Thus, if a request for a destaged data set occurs, the current

copy can still exist, intact, on a staging drive. Data Reuse routines in OS/VS first attempt to locate data in this manner to prevent unnecessary staging. This is analogous to page reclamation in virtual storage management. In VS1 systems data reuse is not invoked for multi-volume data set request or for requests having an esoteric specified.

When the problem program is finished with a data set, it issues a CLOSE macro. The CLOSE macro operates the same as before the Mass Storage System was added to your system. A data set on a virtual volume is not immediately destaged when CLOSE is issued. The data remains on a staging drive until the Least Recently Used algorithm needs to free up the staging space containing the data. If you use VSAM data sets, you may request to wait until the data set is destaged before control is returned from the CLOSE macro or the volume is demounted. In this case, the staging space is immediately queued for destaging. This ensures that you are notified of I/O errors occuring during destaging while your program is still in execution.

A virtual volume remains on a staging drive until OS/VS or the system operator demounts the volume. When a demount request is received, all staging pages containing data from the virtual volume currently mounted are scheduled to be destaged (if required). If a virtual volume is requested by a job while the volume is being destaged, and the request is for the same staging drive group that the volume is being destaged from, the requesting job waits until the destaging is complete. If the virtual volume is requested for another staging drive group other than the one the volume is being destaged from, the job requesting the volume will terminate abnormally.

New Programs to Support the Mass Storage System

There are many new programs that support the Mass Storage System and aid you in the use of the system. These programs define your Mass Storage System to the Mass Storage Control and operating system; handle communications; write reports; keep track of information about virtual volumes; select volumes for space allocation; and assist your control over data cartridges, mass storage volumes, and groups of mass storage volumes.

Mass Storage Control Table Create Program

The Mass Storage Control Table Create program builds two sets of tables on two different 3336 Model 1 Disk Packs. You must run Mass Storage Control Table Create program twice to build the four sets of tables that are necessary for Mass Storage System operation (primary, secondary, and two alternate tables). The tables are identical. In general, the tables describe the configuration and reflect the status of the Mass Storage System.

The Mass Storage Control tables must exist prior to the first Initial Microprogram Load of the Mass Storage Control. The tables must be created on a real drive. Even though a real drive is used, the disk pack must be formatted as a staging pack. The release of IEHDASDR that supports the Mass Storage System must be run to format the disk packs on which the tables are defined so the tables can be used by the Mass Storage System.

The Mass Storage Control Tables packs that were on real drives must be moved to the required staging drives before Initial Microprogram Load of the Mass Storage Control.

The Mass Storage Control tables are in a password-protected data set with the name of SYS1.MSCTABLE.*volser*. *Volser* is the volume serial number of the staging drive on which each set of tables exists. This allows access to all table areas: primary, secondary, and both alternate areas. You should be aware of the Storage System Identification (SSID) of the device that currently contains the primary and secondary tables when you attempt to access the Mass Storage Control tables. There are only four SSID possibilities, which are: 000, 002, 004, 006.

The content of the tables is determined from your control statements. Each time the tables are built after the Mass Storage System is initially installed, the current level of the tables must also be used as input. The Mass Storage Control is constantly updating the contents of the tables while the Mass Storage System operates. If there is to be any rebuilding of the tables (by the Table Create program), the rebuilding must be done when the Mass Storage System has been suspended for reconfiguration. After the tables are rebuilt, there must be a new Mass Storage Control Initial Microprogram Load using the new Mass Storage Control Tables packs. The Mass Storage Control Table Create program is usually only needed at two times: at the initial installation of the Mass Storage System and anytime the hardware configuration of the Mass Storage System is changed. When the Mass Storage Control Table Create program is run, during installation or during reconfiguration of the Mass Storage System, IODEVICE and UNITNAME punched cards are produced for direct input to Stage I of SYSGEN.

When running the Mass Storage Control Table Create program, you must create the input job control stream. There are seven commands that you can specify as input:

- CPUCONFG, which describes each CPU that has a connection to your Mass Storage System.
- CREATE, which indicates whether the Mass Storage Control tables should be initially created or updated.
- DASD, which describes the drives attached to a 3333 Disk Control.
- LOWERCON, which describes the connections between a Staging Adapter and the data recording control in the Mass Storage Facility.
- MSF*n*, which describes a specific Mass Storage Facility in your Mass Storage System.
- SDG*xx*, which describes the Least Recently Used page-freeing values for a given staging drive group.
- UPPERCON, which describes the connections between a Staging Adapter and the operating system.

These seven commands furnish information that is included in the Mass Storage Control tables.

Mass Storage Control Tables

The Mass Storage Control tables have the data set name of SYS1.MSCTABLE*volser*. *Volser* is the volume serial number of the staging drive on which each set of tables exists. This allows access to all table areas: primary, secondary, and both alternate areas. The Mass Storage Control tables are in a password protected data set.

Four basic classifications of data are present in the Mass Storage Control Tables:

- Configuration information, which describes the hardware present in the Mass Storage System and the interconnections between the hardware and functions.
- Media information, which describes the content and location of data cartridges within the cartridge store.
- Activity information, which describes the status of the staging and destaging of data.
- Control information, which contains the information required to locate all the tables and also the basic information required to complete Mass Storage Control Initial Microprogram Load.

Configuration Information

The configuration information relates to the hardware present in the Mass Storage System. *Configuration* is the name given to the physical connections between the units that make up the Mass Storage System. Because of the complex interrelationships existing in the possible hardware configurations, all information relating to the configuration tables must be supplied each time the configuration is changed.

The configuration information includes:

- Staging Drive Group (SDG) table, which describes the location of a group of from one to eight staging drives that are attached to a Staging Adapter. There are several ways staging drives are grouped and attached to a Staging Adapter. You must assign staging drive groups in your Mass Storage System.
- Mass Storage Facility Cell Map, which contains information about the availability of every cell location in the cartridge store. The Mass Storage Facility Cell Map is used to find an available location in the cartridge store for a data cartridge that is entering the Mass Storage Facility through the cartridge access station.
- Configuration Table, which describes the connections between the Mass Storage Control and the Staging Adapters, the Staging Adapters and the CPUs, Staging Adapters to Disk Controls to drives, CPUs to other CPUs, and the paths from Unit Control Blocks (UCB) in the operating system to a specific real drive or to a specific group of staging drives for virtual device addresses.
- Verification Table, which contains a directory to all the tables on the Mass Storage Control table packs, a description of the connections between the Staging Adapters and the groups of staging drives, the virtual-to-real page map for table pages, a list of non-DASD Unit Control Blocks, a description of the connections between a data recording control and its data recording devices, a description of the connections between the Staging Adapters and staging drives, and a bit map of the status of the Staging Adapters, cartridge store, data recording devices and controls, and staging drives.

Media Tables

The Media Tables describe the cell locations of the data cartridges that are present in the cartridge store. For all Mass Storage Control Table Create program updating runs, the Media tables must be available so that they can be copied to the new Mass Storage Control Table volume.

The Media Tables consist of the following:

- Volume Inventory Table, which is the cross-reference list of all active (currently mountable) mass storage volumes to cells within the cartridge store. There is only one Volume Inventory Table per Mass Storage System.
- Scratch Cartridge List, which is a list of all data cartridges that are present in the cartridge store and are not assigned to a mass storage volume. There is one Scratch Cartridge List for each cartridge store. *Scratch cartridges* are data cartridges that contain no useful data and are available for use by the Mass Storage System to make up mass storage volumes. When data is initially being placed in the Mass Storage System, all the data cartridges are scratch cartridges until they are assigned in pairs to make mass storage volumes.

- Transient Volume List, which is a list of all inactive (currently non-mountable) mass storage volumes in the cartridge store. Volumes are put on this list through the use of COPYV or STOREV commands and removed from the list through the use of the ADDV command. These commands are explained in the section "Mass Storage System Service Commands." Volumes are also put on this list when the data cartridges for a volume are entered into the Mass Storage Facility through the cartridge access station. Identification of data cartridges and the XYZ location of each data cartridge is contained on the list. All volumes on the Transient Volume List contain valid data. No volumes on the Transient Volume List can be mounted until they are moved to the Volume Inventory Table. The Mass Storage System ADDV command moves the volume identification to the Volume Inventory Table.

Activity Tables

The Activity Tables reflect the status of the staging and destaging activity within the Mass Storage System. Whenever the Mass Storage Control Table Create program is run, it zeroes out all the Activity Tables. Therefore, all staged virtual volumes on staging drives must be destaged before the execution of the Mass Storage Control Table Create program or there will be no record of the virtual volumes that are staged and destaged. To avoid having to destage all virtual volumes, the Mass Storage Control Table Create program can be run before processing begins on the Mass Storage System or at the end of the day when all Mass Storage System processing has finished.

The Activity Tables consist of the following:

- Mounted Volume Table, which contains entries for all virtual volumes that have been staged and are not yet destaged. This is a list of all virtual volumes that are still on staging drives. It is this table that is used for Data Reuse.
- Virtual Unit Address Table, which is a bit map that indicates the availability or unavailability of each of the virtual volume addresses that are assignable through a Staging Adapter.
- Virtual Volume Address/Volume Identification Cross-Reference Table, which relates virtual volume addresses by Staging Adapter to the corresponding entry in the Mounted Volume Table.
- Schedule Queue Table, which holds the staging/destaging queues for each Mass Storage Facility. There is one staging/destaging queue for each Mass Storage Facility.
- Trace Table, which contains records indicating completed data cartridge movement and staging and destaging activity.
- Recovery Journal, which contains the previous contents of table blocks as they are modified during the execution of an order. Should the order fail, the updated blocks are backed out of the affected tables by applying the contents of the Recovery Journal in a last-in-first-out sequence.
- Staging Adapter Page Status Table Image Area, which is used by the Mass Storage Control to read the Staging Adapter Page Status Table.

Control Information

The Verification Table contains all the control information required by the Mass Storage Control to complete the Initial Microprogram Load procedure and to find the starting locations of all the other tables.

Mass Storage System Communicator

The Mass Storage System Communicator (MSSC) is a new component of a system control program that handles the communications between the operating system and the Mass Storage Control, keeps track of all mass storage volumes, and selects volumes from mass storage volume groups to satisfy requirements for new data set space. The Mass Storage System Communicator resides in main storage and is called only when Mass Storage Control functions are required.

One of the major functions of the Mass Storage System Communicator is to aid in managing the many mass storage volumes. Because the Mass Storage System capacity for mass storage volumes is so high, centralized control of the volumes is required.

A set of functions in the Mass Storage System Communicator maintains information for each mass storage volume that is identified to the Mass Storage System. For ease of distinguishing this set of functions from the other jobs of the Mass Storage System Communicator, this set of functions is called the Mass Storage Volume Control. The prime objective of the Mass Storage Volume Control functions is to make an intelligent selection of a volume for non-specific non-VSAM volume requests for new data sets. The selection of a volume is based upon the amount of space available on the volume for the data set.

The Mass Storage Volume Control functions maintain two data sets: the *Mass Storage Volume Inventory* data set (usercat.MSVI) and the *Mass Storage Volume Control Journal* data set (usercat.MSVCJRNL). Hereafter, these two data sets are called the Inventory and Journal data sets. This set of functions and the two data sets enable the Mass Storage System Communicator to aid in managing the mass storage volumes.

The Inventory data set can reside on a mass storage volume or a drive that may or may not be under the control of the Mass Storage System. The drive that contains the Inventory data set must be sharable by each CPU using the Mass Storage System. There is only one Inventory data set for each Mass Storage System.

A higher level of control is provided in the Inventory data set for mass storage volumes by assigning the volumes to mass storage volume groups, hereafter called *groups*. Groups are collections of mass storage volumes that have some characteristics in common. The common characteristics can be how the data sets on the volumes are used, who uses the data sets, the size and type of data set, or any characteristics that you desire. For each group, information is contained in a group record in the Inventory data set. The information in the group record applies to all the mass storage volumes assigned to that group. A mass storage volume may or may not belong to a group, but the volume is restricted to only one such group.

Groups are created and mass storage volumes are assigned to the groups by the space manager. Once the groups are created and volumes are added to the group, the assignment of new non-specific non-VSAM data sets to the volumes is easier. Also, the job of the space manager is easier in that he does not have to try to manage all the mass storage volumes in the cartridge store, but can manage the data cartridges as mass storage volumes and mass storage volume groups. A complete description of the duties of the space manager is contained in the section "What New Responsibilities Are Introduced?".

You may or may not choose to use groups in your Mass Storage System, but there is one group that is established and should contain mass storage volumes even if the volumes contain no data. That group is SYSGROUP. SYSGROUP is used by the Mass Storage System as a default group.

Mass Storage Volume Control Recovery and Maintenance Functions

There are six functions that can be used for error recovery and maintenance for the Mass Storage Volume Control Inventory and Journal data sets.

The functions are:

- DISABLE or DISABLEJ
- ENABLE
- RECOVER
- BACKUP
- PRINT

The DISABLE function allows the Inventory data set to be taken offline for recovery purposes. In this process, I/O to the Inventory data set is curtailed and the Mass Storage Volume Control data sets are closed and deallocated. The DISABLEJ function takes the Journal data set offline.

The ENABLE function brings the Mass Storage Volume Control data sets back online for normal processing without the need for a re-Initial Microprogram Load. This is done by reallocating and reopening the data sets to allow I/O operations to be executed.

The RECOVER function recreates an Inventory data set from a down-level Inventory data set and the requests list from the Journal data set. The requests list from the Journal data set is a list of requests that cause creation, modification, or deletion of records. Mass Storage Volume Control functions must be disabled, the Access Method Services IMPORT command must be executed to create a down-level Inventory data set, then the RECOVER function is invoked to update the Inventory data set from the requests list in the Journal data set and to print the messages for the space manager that are in the Journal data set. The messages for the space manager are about the status of the Inventory and Journal data sets. The Journal data set is not nulled during the recovery operation. In order to null the Journal data set, the BACKUP function should be executed.

The BACKUP function prints Journal data set messages for the space manager and nulls the Journal data set. Mass Storage Volume Control functions must first be disabled, the Access Method Services REPRO or EXPORT command must be executed to create a backup Inventory data set, then the BACKUP function is invoked to print messages for the space manager that are in the Journal data set. The Journal data set is then nulled. The ENABLE function must then be executed to bring the Mass Storage Volume Control data sets back online for processing.

The PRINT function prints the messages for the space manager without disrupting normal Mass Storage Volume Control processing. The messages for the space manager are printed and removed from the Journal data set but the Journal data set is not nulled. In order to null the Journal data set, the BACKUP function should be executed.

Mass Storage System Services

The Mass Storage System Services commands assist the space manager in the areas of mass storage volume group management, mass storage volume management, data cartridge management, and data set management. Many reports are provided by the Mass Storage System service commands and although the reports form an integral part of mass storage volume group management, mass storage volume management, and data cartridge management, they are described separately. Based on the status provided by the reports, recovery services can be invoked. Because of the sensitive nature of these commands, they are not available as part of the Time Sharing Option terminal command language as other Access Method Services commands are.

All Mass Storage System Services commands are protected by the Authorized Program Facility (APF). In VS2 systems all commands that use password protection are also protected by the Resourse Access Control Facility (RACF).

The use of the command is described in general in the publication *OS/VS Mass Storage System (MSS) Services: General Information*, and in detail in the publication *OS/VS Mass Storage System (MSS) Services: Reference Information*.

Group Management Commands

Mass storage volumes can optionally be assigned to mass storage volume groups. Groups are collections of mass storage volumes that have some characteristics in common. The common characteristics can vary as widely as you want them to. They can be based on such characteristics as the type of data contained in the volumes, the users of certain volumes, the job types, or any other characteristics that you want to use to define a group. By having groups, the work of the space manager and application programmer is simplified in that the application programmer does not have to specify all the parameters required to create a new data set and that the space manager does not have to manage all the mass storage volumes in the Mass Storage Facility but can manage the groups as subsets of the total number of volumes.

Group management commands enable the space manager to create new groups, modify the characteristics of existing groups, delete groups, and initialize the allocation to mounted volumes support. Volume management commands must be used to assign mass storage volumes to a group, move mass storage volumes between groups, or remove a mass storage volume from a group.

All mass storage volume group management commands have the suffix "G".

The CREATEG Command

The space manager creates user-defined groups with the CREATEG command. The CREATEG command creates a group record that contains the group description in the Inventory data set. The group contains no volumes when it is initially created. It is essentially just a record in the Inventory data set. The space manager must assign mass storage volumes to the group. The space manager uses the CREATEV and MODIFYV commands to assign mass storage volumes to the group. See "Volume Management Commands" later in this section.

SYSGROUP is not created by the space manager but the space manager must assign volumes to SYSGROUP. SYSGROUP is created with the System Generation of the Mass Storage System.

The CREATEG command is used to intialize the allocation to mounted volumes support for the new groups.

The MODIFYG Command

The MODIFYG command changes the group information that is recorded in the Inventory data set. You can change information that the CREATEG command initializes when the group is created and you can change the group information of SYSGROUP even though this group is not created with the CREATEG command.

You can also use the MODIFYG command to initialize the allocation to mounted volumes support for existing groups.

The SCRATCHG Command

The SCRATCHG command deletes a group from the Inventory data set. No mass storage volumes can still belong to the group to be scratched. Any user-defined group can be scratched. SYSGROUP cannot be scratched.

Volume Management Commands

The mass storage volumes within a Mass Storage System can be divided into two types: active volumes and inactive volumes. *Active* mass storage volumes can be mounted and are on the Volume Inventory table. *Inactive* mass storage volumes cannot be mounted and may or may not be in the Mass Storage Facility. If the inactive volume is in the Mass Storage Facility, it is on the Transient Volume List. Both active and inactive volumes can be in the Inventory data set.

Volume management commands allow the space manager to manipulate mass storage volumes. For example, they create, convert, copy, and delete volumes. They also allow the space manager to assign mass storage volumes to a group, move mass storage volumes between groups, or remove a mass storage volume from a group.

The mass storage volume management commands have the suffix "V".

The ADDV Command

The ADDV command changes the status of a mass storage volume from inactive to active so that the volume can be mounted. If the inactive volume has the same serial number as another volume in the Inventory data set, and the inactive volume is not a copy of the volume that is in the Inventory data set, the serial number of the inactive volume must be changed.

When a base mass storage volume has had its cartridges reassigned or ejected from the Mass Storage Facility with the NULLIFYC or EJECTV commands, use the ADDV command to activate a copy volume as the base with the same volume serial number.

The CONVERTV Command

The CONVERTV command converts (1) a volume on a 3336 Model 1 Disk Pack to a mass storage volume, or (2) a mass storage volume to a volume on a 3336 Model 1 Disk Pack. All the data on the volume being converted is moved without reorganization from the source volume to the target volume and, optionally, the data sets on the target volume are recataloged and the source volume data sets are scratched. None of the data movement involves main storage. The buffer of the Staging Adapter handles the data transfer.

The CONVERTV command works only with 3336 Model 1 Disk Packs. For any other type of pack, Access Method Services, OS/VS utilities, or OS/VS JCL in an application program must be used to convert to the mass storage volume by moving a data set at a time. Converting from a mass storage volume to any other pack except a 3336 Model 1 Disk Pack, must also be

done with Access Method Services, OS/VS utilities, or OS/VS JCL in an application program.

The 3336 Model 1 Disk Pack that is involved in the conversion must be on a convertible drive that is varied on as real. Both of the volumes that are involved in the conversion, real and mass storage volume, must not be mounted for any other job.

The Volume Table of Contents (VTOC) of the volume being converted assumes the same physical location on the target volume as it had on the source volume. Thus, a mass storage volume containing data converted by the CONVERTV command could have its Volume Table of Contents in the middle of the volume. This is an undesirable location of a Volume Table of Contents for the performance of the Mass Storage System. The Volume Table of Contents should be at the beginning of the volume because cylinder 0 is automatically staged during the mount process. To avoid having the Volume Table of Contents in the middle of the volume, you can use existing system utilities to move each data set from the real 3336 Model 1 Disk Pack to a mass storage volume.

The data sets on the source volume can be scratched after the volume has been converted successfully. However, you can elect not to scratch the data on the source volume. This allows you to check out the converted volume first.

The COPYV Command

The COPYV command makes a copy of an active mass storage volume. The copy can either be stored in the cartridge store or it can be ejected through the cartridge access station. The copy has the same volume serial number as the original mass storage volume. Because no two active volumes can exist in the Mass Storage System with the same volume serial number, the copy becomes an inactive volume and cannot be mounted by the operating system. The copy is recorded in the Inventory data set and the Transient Volume List.

When a copy of a mass storage volume is made, the CPU is not used. The mass storage volume of which a copy is to be made, is staged to a staging drive, then the data is staged back to the data cartridges that are used to make the copy.

You can specify that the copy is to be a backup copy. The COPYV command will then either create a new backup copy or replace a previous backup copy with the one being created if the specified number of backup copies already exists. The maximum number you can have is nine copies.

The CREATEV Command

The CREATEV command takes two scratch data cartridges and defines them to the Mass Storage System as an active mass storage volume. The mass storage volume is given a unique volume serial number that is entered in the Inventory data set. You can optionally specify the scratch data cartridges that are to be used for the mass storage volume. If you do not, the Mass Storage Control picks the data cartridges from the Scratch Cartridge List. Initially, the new mass storage volumes contain no data; the CREATEV command formats the volumes for use by using the parameters you supply or the defaults to the parameters. After the CREATEV command has finished, the mass storage volume that is created can be mounted. This is the only way mass storage volumes can be created for the Mass Storage System.

The CREATEV command optionally assigns each new mass storage volume to a mass storage volume group that is defined in the Inventory data set. The mass storage volume can be assigned to a user-defined group or to the system-defined group called SYSGROUP or to no group at all.

A mass storage volume that is assigned to a group can be designated as a general-use volume or a restricted-use volume. Mass storage volumes that are not assigned to a group are neither general-use or restricted-use volumes.

General-use mass storage volumes are used by the Mass Storage Volume Control functions to allocate data sets for non-specific volume selection. All general-use mass storage volumes are assigned the Mass Storage System attributes defined for the group.

Restricted-use mass storage volumes are not used by the Mass Storage Volume Control functions for non-specific volume requests; they are used for specific volume requests. Restricted-use volumes must be requested by volume serial number. You must assign Mass Storage System attributes when creating restricted-use volumes or volumes that do not belong to any group.

For any mass storage volume, whether it is assigned to a group or not, you can use a parameter of the CREATEV command to define the number of backup copies you want to retain for the volume. The backup copies are made by using the COPYV command. The maximum number you can assign is nine.

The EJECTV Command

The EJECTV command ejects an inactive mass storage volume from the cartridge store through the cartridge access station.

Both data cartridges of a mass storage volume are normally ejected from the cartridge store. You can retain a record of the ejected volume in the Inventory data set along with a description of the location of the volume outside the cartridge store. If there is only one data cartridge of a mass storage volume in the cartridge store, the EJECTV command ejects that one data cartridge. You are notified that only one data cartridge has been ejected.

The MODIFYV Command

The MODIFYV command changes information in the Inventory data set about an active mass storage volume. You can change any of the information that was specified in the CREATEV command.

The MODIFYV command also enables you to repair the volume label when it is unreadable.

The RECOVERV Command

The RECOVERV command copies the data from an inactive copy of a mass storage volume to an active mass storage volume. In other words, the RECOVERV command does essentially the opposite of the COPYV command. The active volume to be copied to, can be the original volume that was used to make the copy or it can be another active volume.

The handling of the data is the same as in the COPYV command. The data from the inactive copy is staged to a staging drive and then destaged to the receiving mass storage volume. This data transfer, as with the COPYV command, is accomplished without the use of the CPU. The copy that is

used in the data transfer remains an inactive copy of a volume. The volume that received the data is still an active volume. If the data is being copied to a volume that is not the original volume, the receiving volume must not contain any data sets and it cannot be a volume owned by a VSAM catalog.

The REMOVEVR Command

The REMOVEVR command removes one or more volume records from the Inventory data set. The mass storage volumes whose records are removed must not be in the cartridge store. The records must belong to volumes that were ejected from the cartridge store by the EJECTV, STOREV, or COPYV commands. This command allows the removal of records that were maintained in the Inventory data set for information. The record of the volume can be removed only if there are no copies recorded for the volume in the Inventory data set.

During the processing of the commands ADDV, CONVERTV, COPYV, CREATEV, MODIFYV, or STOREV temporary records are created and added to the Inventory data set. These records are known as placeholder records. They are created to ensure that no other CPU can access the volume being processed. When processing completes, the placeholder records are deleted and the appropriate volume records are added. If an operating system failure occurs before the processing completes, use REMOVEVR to remove the placeholder records.

The REPAIRV Commands

The REPAIRV command enables you to correct mass storage volume records that have stage or destage errors. The four options of the REPAIRV command are:

- REPAIRV DISPLAY–which locates and lists the volume records having stage and destage errors. These records are written to the SYSPRINT data set or an alternate data set specified by you. This command option should be run after each of the other REPAIRV command options to ensure that what you wanted to occur did occur.
- REPAIRV COPY–which copies the volume records having stage or destage errors into a work area called *repair workfile*.
- REPAIRV DEBLOCK–which segments the track image of concatenated stage error records into the original records. Before using this command option, the stage error record must have been copied into the repair workfile using the REPAIRV COPY command option.
- REPAIRV MODIFY–which modifies the contents of the volume records having stage or destage errors. This command option is used to correct the contents of records in the repair workfile and update the record with the corrected data from the repair workfile. You can also correct an error directly in the VTOC.

The SCRATCHV Command

The SCRATCHV command returns the data cartridges that were a mass storage volume to the pool of scratch data cartridges and removes the volume record from the Inventory data set. The mass storage volume that is returned to scratch data cartridges must have been either an active volume or a copy of a volume. The active volume must not have any data sets on it, or have any copies recorded for it, and it must not be a volume that is owned by a VSAM catalog. The copy must be made by the COPYV command and recorded in the Inventory data set as a copy.

The STOREV Command

The STOREV command makes an active volume inactive and not mountable. The volume is marked inactive in the Inventory data set. The STOREV command can optionally eject the volume from the cartridge store. If the volume is ejected, the STOREV command can optionally keep a record of the ejected volume in the Inventory data set with a description of the location of the volume outside the cartridge store, or remove the record of the ejected volume from the Inventory data set.

Non-VSAM Data Set Handling Commands

To aid the space manager in managing sapce on a mass storage volume, the SCRDSET command scratches non-VSAM data sets from an active volume. This command is used in conjunction with the LISTDSET command. The LISTDSET command lists information about non-VSAM data sets, and the SCRDSET command scratches and uncatalogs non-VSAM data sets.

The LISTDSET Command

The LISTDSET command lists information about non-VSAM data sets on active mass storage volumes. This command can be used to find data sets that can be scratched by the SCRDSET command. The non-VSAM data sets are found by reading the Volume Table of Contents of the mass storage volumes.

The LISTDSET command produces reports with data set information printed in columns. The data sets are listed in alphanumerical order on a separate page for each volume.

You can specify the volumes containing the data sets to be listed by volume or group name. If you don't know the volumes assigned to a particular group, you can supply a group name and the LISTDSET command determines, from the Inventory data set, the general-use and restricted-use volumes that are assigned to the group.

You can list either all non-VSAM data sets that are recorded on the Volume Table of Contents or you can list only those non-VSAM data sets that meet certain criteria. The criteria you can specify are: specific leading and trailing name qualifiers, creation on or before a certain date, expiration on or before a certain date, and whether the data set is cataloged. These criteria can be specified singly or in combination. If more than one criterion is specified, data sets are listed only if they meet all the criteria.

The LISTDSET command produces two reports.

The Status Report. The information for the Status Report is obtained from the volume table of contents and the VSAM catalog. This report lists the volume containing the data set, the data set name, the creation and expiration date of the data set, whether the data set is cataloged, the type of protection for the data set, and the owner of the data set.

The Space Usage Report. All the information for the Space Usage Report is obtained from the volume table of contents. This report lists: the volume name, data set name, data set organization, type of space unit (absolute tracks, blocks, cylinders, or tracks) in which the data set was allocated to the volume, the number of extents allocated for the data set, the number of blocks, tracks or cylinders that are assigned for any secondary space allocation, the total number of tracks allocated for each data set, and the number of free tracks for each data set. At the end of the report a summary is printed. The summary information contains: (1) the amount of

space allocated to the listed data sets and to the Volume Table of Contents, (2) the amount of free space left on the volume, (3) the number of free data set control blocks (DSCBs) in the Volume Table of Contents, and (4) the number of free extents and the largest contiguous free extent.

The SCRDSET Command

The SCRDSET command scratches and uncatalogs non-VSAM data sets on active mass storage volumes. The non-VSAM data sets are found by reading the Volume Table of Contents of the mass storage volumes. When a cataloged data set is scratched, it is uncataloged from either a VSAM catalog or an OS CVOL catalog. If the data set is not cataloged, the data set is just scratched.

The volumes containing data sets to be scratched can be specified by either volume or group name. If the group name is specified, the SCRDSET command determines from the Inventory data set, the general-use and restricted-use volumes assigned to that group. The data sets on their volumes are then scratched.

You can scratch and uncatalog either all non-VSAM data sets or only those non-VSAM data sets that meet certain criteria. The criteria you can specify are: specific leading and trailing name qualifiers, creation on or before a certain date, expiration on or before a certain date, whether the data set is cataloged or not, and whether the data set has a system generated name. These criteria can be specified singly or in combination. If more than one criteria is specified, data sets are scratched only if they meet all the criteria.

Data Cartridge Management Commands

Two data cartridge management commands allow the space manager to eject one or more scratch data cartridges from the cartridge store and to replace old or defective data cartridges with scratch data cartridges. Scratch data cartridges are data cartridges that contain no useful data. They are in the cartridge store to be used by the space manager in the creation of mass storage volumes.

The data cartridge management commands have the suffix "C".

The EJECTC Command

The EJECTC command ejects scratch data cartridges from a cartridge store through the cartridge access station. The parameters of the EJECTC command allow you to eject from one to all scratch data cartridges from the cartridge store through one use of the command.

The MODIFYC Command

The MODIFYC command is used to change the cartridge label. The label may require changing because the label is inconsistent with the Mass Storage Control tables or because it is unreadable. This command can be used to move a cartridge from one cell location to another, or to move a cartridge from a cell location to the cartridge access station.

When any changes are made using the MODIFYC command, the corresponding changes to the Mass Storage Control tables and Inventory data set are not made. When this command is used it is the responsibility of the space manager to update the appropriate tables and the Inventory data set.

The NULLIFYC Command

The NULLIFYC command purges all existing records about a cartridge. The command should be used only if the cartridge is physically out of the Mass Storage Facility. The cartridge must be removed before issuing the NULLIFY command. If both cartridges that make up a mass storage volume are not in the Mass Storage Facility, one NULLIFYC command purges both cartridge records.

If you have the situation where both cartridges of a volume are in the Mass Storage System and you want to return the volume to scratch status, the NULLIFYVOLUME parameter is available. The volume and its cartridges are returned to scratch status without any password checking. Be sure that the volume requires nullification.

The REPLACEC Command

The REPLACEC command replaces one data cartridge of an active mass storage volume with another data cartridge. The data cartridge to be replaced is normally a defective or an old data cartridge. The SYS1.LOGREC data set identifies defective and old data cartridges.

Defective data cartridges are data cartridges to which one or more cylinders could not be destaged. The REPLACEC command stages all unstaged data from the defective data cartridge to a staging drive. When the new data cartridge is chosen, the data from the defective data cartridge on the staging drive is destaged to the new data cartridge. Then the data that could not be destaged to the defective data cartridge is destaged to the new data cartridge. The System Data Analyzer reports point to data cartridges that are experiencing more than normal staging and destaging errors. By using these reports, a defective data cartridge can be replaced before it reaches the point when it will not accept data to be destaged. The System Data Analyzer is described in the section "Mass Storage System Data Analyzer."

Old data cartridges are data cartridges that have reached a certain age or have been accessed a certain number of times. These data cartridges should be replaced before they can cause errors.

If you have to replace both data cartridges of a mass storage volume, you must specify this command twice.

Status Commands

Several commands provide reports and outputs that aid the space manager in determining the contents and status of the Mass Storage System. These reports and outputs enable the space manager to manage mass storage volumes, groups, and data cartridges by listing cartridges and their location, the contents of the Mass Storage Control tables, the Staging Adapter tables, and the Inventory data set. In addition, the commands provide a comparison of the primary and secondary Mass Storage Control tables, formatted and unformatted dumps of these tables, and dumps of the Mass Storage Control and Staging Adapter storage.

The AUDITMSS Command

The AUDITMSS command is used to ensure that a data cartridge is in its proper cell in the Mass Storage Facility. You can issue the AUDITMSS command to do one of the following:

- You can compare the empty or occupied cells, as they are indicated in the Mass Storage Control tables, with the actual cells in the Mass Storage Facility. Any discrepancies between the tables and the Mass Storage Facility can be checked and reported.
- You can print a map of cells based on the Mass Storage Control tables. The map indicates whether each cell is occupied or empty.
- You can have each cartridge label read to verify that the correct cartridge is in the correct cell. AUDITMSS compares the cell address of the data cartridge as it is recorded in the cartridge label with the cell address the cartridge was taken from. You can list each cartridge serial number audited. Discrepancies are printed.

The CHECKMSS Command

The CHECKMSS command compares the Mass Storage Control tables, the Staging Adapter tables, and the Inventory data set for inconsistencies. This command can check the Inventory data set against the Mass Storage Control tables, the Staging Adapter tables against the Mass Storage Control tables, and the Mass Storage Control tables can be checked against themselves and within themselves. Inconsistencies are reported.

The CHECKMSS command makes a copy of the Mass Storage Control tables and the Staging Adapter tables so that the tables cannot change while they are being checked. You should not run any Mass Storage System Access Method Services commands that change the Inventory data set while the checks are being made. If you do, inconsistencies will show up between the Inventory data set and the tables.

The DUMPMSS Command

The DUMPMSS command lists the contents of storage from the Mass Storage Control, the Staging Adapters, the Mass Storage Control tables, or selected portions of each. The only requirements for dumping the contents of the Mass Storage Control are that the Mass Storage Control must be active (operable) and the Mass Storage Control must be the primary Mass Storage Control. The Mass Storage Control and Staging Adapter storage can be dumped unformatted or formatted. The Mass Storage Control tables are dumped unformatted.

The LISTMSF Command

The LISTMSF command lists the physical contents of the cartridge store. If you have more than one Mass Storage Facility, you must specify which Mass Storage Facility you want listed. The LISTMSF command lists the identification of all the mountable mass storage volumes, all the non-mountable mass storage volumes, all the scratch data cartridges, and summary information. This information is retrieved from the Mass Storage Control tables. The LISTMSF command automatically copies the tables to a virtual volume that you have specified. The LISTMSF command takes the information from the copy of the tables and uses it for the lists.

Four lists of information are available:

Mountable Mass Storage Volumes. These are mass storage volumes that can be mounted and are on the Volume Inventory Table. The mass storage volumes are listed by volume serial number in alphanumeric order. The LISTMSF command prints the total number of mountable volumes that are in the cartridge store and the volumes' XYZ locations.

Non-mountable Mass Storage Volumes. This is a list of all the mass storage volumes that are on the Transient Volume List. These volumes cannot be mounted. The volumes on this list consist of volumes stored through the use of the STOREV command, copies that have been made through the use of the COPYV command, and volumes that have been manually entered into the cartridge store through the cartridge access station and are still inactive. The volumes are listed by serial number in alphanumeric order. For each volume listed, the LISTMSF command lists the staging attributes, the serial number of the first data cartridge that makes up the volume, and the XYZ locations of both data cartridges. If only one data cartridge of a volume has been entered into the cartridge store, the LISTMSF command lists the XYZ location of only one data cartridge.

From this report, you can get the serial number of the first data cartridge that makes up a volume. This serial number may be needed when you use the ADDV or EJECTV commands. The LISTMSF command also prints the total number of non-mountable volumes that are in the cartridge store.

Scratch Data Cartridges. This is a list of all the data cartridges on the Scratch Cartridge List. The data cartridges are listed by serial number in alphanumeric order with the XYZ location. You use these scratch data cartridges for creating new mass storage volumes through the use of the CREATEV command, for making copies of existing volumes through the use of the COPYV command, and for replacing old or defective data cartridges through the use of the REPLACEC command. The LISTMSF command also prints the total number of scratch data cartridges that are in the cartridge store.

Summary Information. The LISTMSF command prints the number of mountable mass storage volumes, the number of non-mountable volumes, the number of scratch data cartridges, and the number of empty cells. From the summary information you can get an indication of when you need to enter more scratch data cartridges, eject data cartridges, or make other adjustments within the cartridge store.

The LISTMSVI Command

The LISTMSVI command lists the volume management information for all volumes maintained in the Inventory data set. The LISTMSVI command lists information required by the space manager to manage volumes whether they are in the cartridge store or have been ejected from the cartridge store. The volumes that have been ejected from the cartridge store can be listed if the space manager has chosen to retain information in the Inventory data set about the ejected volumes. The LISTMSVI command lists volume management information for all data cartridges known to the Mass Storage Volume Control functions except scratch cartridges.

You should not modify the status of mass storage volumes while the LISTMSVI command is reading the Inventory data set.

The LISTMSVI command prints two types of reports: Space Usage Report and Inventory Status Report. Each report contains a subset of all the information in the Inventory data set.

Inventory Status Report. This report lists the status of mass storage volumes, groups, or cartridges that are in the Inventory data set. The information listed includes: the volume and/or group characteristics defined by the space manager, the data cartridges that make up the volumes, the locations of each volume, and the copies that have been made of each volume. This report is actually a summary of the operations performed by the space manager through the use of the Mass Storage System service commands. The space manager can use this report to see if volumes were assigned to the correct groups, if the correct number of copies were made, as a general reference for the work accomplished through the service commands, and as a pointer to areas where possibly more work should be done.

Space Usage Report. This report lists information about the use of space on the volumes in the Inventory data set. The information listed includes the space-related characteristics defined by the space manager and information maintained in the Inventory data set about the amount of space that is available on each volume and on all the general-use volumes in a group. The information in this report changes as data sets are allocated and scratched. Thus, this report is requested more often than the Inventory Status Report. From this report, the space manager can identify areas where volumes must be added to groups to provide more space and where groups have too many volumes assigned and too much space.

Initially, you will probably use the LISTMSVI command frequently and get all the reports it produces. But as time progresses, you will recognize certain areas that must be watched more closely than others. These areas depend on your computing system, the type of data, and how the system and data are used. Once you have determined which report is desired, you can specify the volumes and groups to be listed. You can specify one of these six options:

All Mass Storage Volume Serial Numbers Can Be Listed. The ALLVOLUMES option of the LISTMSVI command lists all the volumes recorded in the Inventory data set by volume serial number in alphanumeric order. You can further specify that the LISTMSVI command select for listing only those volumes that do not belong to a group or only duplicate volumes.

In addition, you can specify the PLACEHOLDER parameter which restricts the Inventory Status Report to placeholder records. Otherwise, placeholder records are listed in alphanumeric sequence by volume serial number along with the other volumes listed on the report.

Specific Mass Storage Volume Serial Numbers Can Be Listed. The VOLUMES option of the LISTMSVI command lists only specific volume serial numbers in the sequence in which they were requested.

All Mass Storage Volume Group Names Can Be Listed. The ALLGROUPS option of the LISTMSVI command lists all the groups that are recorded in the Inventory data set by group name in alphanumeric sequence. The command can optionally list information about the volumes that have been assigned to a group. You can specify which type of volume within the group to list: all volumes, active volumes, inactive volumes, general-use volumes, or restricted-use volumes.

Specific Mass Storage Volume Group Names Can Be Listed. The GROUP option of the LISTMSVI command lists only the specific group names requested in the sequence in which they were requested. The command can optionally list information about the volumes that have been assigned to a group. You can also specify which volumes within the groups to list: all volumes, active volumes, inactive volumes, general-use volumes, or restricted-use volumes.

A listing of the entire Inventory data set is obtained in one of two ways: (1) you can obtain one listing with all volumes listed by volume serial number in alphanumeric sequence, or (2) you can obtain three reports, each by volume serial number in alphanumeric order, one report of all groups showing all volumes in each group, a second report of all volumes that are not part of a group, and a third report of all duplicate volumes in the cartridge store.

All Data Cartridges Can Be Listed. The ALLCARTRIDGES option of the LISTMSVI command is used to list all cartridges assigned to mass storage volumes that have records in the Inventory data set. The command lists the cartridges in cartridge serial number sequence.

Unlike the other LISTMSVI command options, the ALLCARTRIDGES option does not have two reports. Only an inventory status type of report is provided. Therefore, if the REPORT parameter is specified with this command, it is ignored.

The ALLCARTRIDGES option provides a list containing: the cartridge serial number, volume identification, location of the cartridge, active or inactive status for base volume cartridges, mounting attributes for base and copy volume cartridges, owner of base or copy volume cartridges, and volume type (general-use, restricted-use, copy, duplicate, or backup).

Specific Data Cartridges can be listed. The CARTRIDGE option of the LISTMSVI command is used to obtain a report on specific cartridges in the Inventory data set. This report will not be in cartridge serial number sequence, but the cartridges will be listed in the order they are specified in the command.

The same information is listed for specific cartridges as that listed for all cartridges. As with the ALLCARTRIDGES option, only an inventory status type of report is produced.

Table Recovery Commands

Recovery commands available to the system programmer help locate, and resolves problems with the Mass Storage Control tables, and identifies problems that might degrade the efficiency of the Mass Storage System. They also initiate trace activities inside the Mass Storage System and allow the system programmer to tune the Mass Storage System to meet his needs. The Table commands have the suffix "T".

The COMPARET Command

The COMPARET command makes a copy of the primary and secondary Mass Storage Control tables and compares the two copies. The Trace and Journal data set records, schedule queues, and message buffer tables are not compared. Any discrepancies between the two tables are reported.

To receive only valid discrepancies between the two tables, you should issue the COMPARET command when there are no Mass Storage System jobs running.

The COPYT Command

When the Mass Storage Control detects an error in its tables, a message is issued indicating the need to run the COPYT command. If the primary Mass Storage Control tables have an error, the COPYT command makes the secondary Mass Storage Control tables the primary tables and copies the new primary tables as the secondary tables. If the secondary Mass Storage Control tables have an error, the COPYT command makes a copy of the primary tables and makes that copy the secondary tables. The COPYT command is the only command accepted by the Mass Storage Control after a tables error has been detected.

The SWAPT Command

The SWAPT command exchanges the designation of the primary and secondary Mass Storage Control tables. The tables are not moved. The primary tables become the secondary tables and the secondary tables become the primary tables.

Tracing and Tuning Commands

The Mass Storage System controls and maintains the activities of its queues and tables. Unless an error occurs, the CPU is not informed of this activity. The TRACE command turns on or off the hardware trace that records the activities of the queues and tables of the Mass Storage System. It also dumps the information to a data set so that you can get reports.

During the operation of the Mass Storage System, the needs of the operating system vary. At peak operating periods, the operating system needs vast amounts of data and at other than peak periods, the demands for data are less. The TUNE command allows you to display and change parameters that affect the performance of the Mass Storage System.

The TRACE Command

The TRACE command controls the gathering of information about the activities that occur within the Mass Storage System. The Mass Storage System TRACE is started or stopped with the Access Method Services TRACE command. Two areas, each 4 cylinders in length, are set aside in the Mass Storage Control table area. These areas are known as TRACEX and TRACEY.

The ON parameter of the TRACE command turns on the trace. When the trace is on, TRACEX is first used to record activity. When TRACEX is full, TRACEY is then used for recording. A message is sent to the primary CPU each time the storage area changes.

With only these two trace areas to work in (TRACEX and TRACEY), data is recorded in first TRACEX and then TRACEY. When the limits of TRACEY are reached, the recording begins again in TRACEX. This means if you do not dump the data that was in TRACEX before the recording areas are switched the second time, that data is lost when TRACEX is overwritten. Remember, the message is sent to the primary CPU after the recording areas are switched.

If you want to know the contents of the TRACE recording areas, you must run the TRACE command to dump the areas. You can dump an area while trace information is being recorded in that area. You will get, as data, everything that has occurred up to the point where the recording is taking place. The TRACE Report program allows you to format the data and print reports from it. The TRACE Report program is described in the section "The TRACE Reports."

The TUNE Command

The TUNE command displays and changes parameters that affect the Mass Storage System performance. These parameters control how much allocatable space is available on staging drives and how virtual volumes are selected for destaging when more allocatable space is needed.

You always want to have an adequate amount of allocatable space available on the staging drive so that staging requests can be handled without delay. You can control the amount of allocatable space that is maintained for each staging drive group by specifying the maximum number of active pages allowed in a staging drive group. The parameters of the TUNE command are used to specify the maximum number of active pages allowed in a staging drive group. The Mass Storage Control manages space in terms of space within a staging drive group.

If enough demounts do not occur to maintain the amount of allocatable space in a staging drive group, the Mass Storage Control uses an algorithm, called the Least Recently Used, to determine which pages should be made available for allocation. When you issue the TUNE command, you can specify the amount of allocatable space to be maintained at all times so that no processing time is lost for staging requests.

A timestamp is assigned to each active page on a staging drive whenever a page is referenced. The value in the timestamp is determined from a "clock" that is maintained by the Mass Storage Control for use by the Least Recently Used (LRU) algorithm. The clock consists of 16 units. Each unit consists of a number of seconds. You specify the number of seconds in each unit. The clock value is incremented by 1 each time the specified number of seconds elapses. When the seconds specified in all 16 uniits have elapsed, the clock is reset. There is only one clock for each Mass Storage System.

Conceptually, think of the Least Recently Used Clock as a clock with 16 divisions instead of 12. Instead of the hand continually sweeping as with a normal second hand on a clock, it advances to the next time as frequently as you specify. Let's say that you specify an increment of 256 seconds. Then any page referenced between now and 256 seconds is timestamped '1,' any page referenced between 256 and 512 seconds is timestamped '2,' and so forth. Figure 9 illustrates the Least Recently Used Clock.

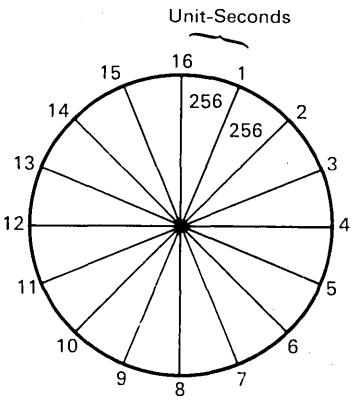


Figure 9. Sample Least Recently Used Clock

When there is a need to destage active pages in a staging drive group, the Mass Storage System uses the Least-Recently-Used algorithm to subdivide the active pages into from one to four groups. This subdivision is made in terms of the active pages' timestamps.

Two examples of these groups are the oldest group and the next oldest group. The Least Recently Used algorithm first destages active non-bound pages in the oldest group, then if needed, destages pages in the next oldest group, and so on until the low-threshold of active pages is met. The low-threshold value is specified with the ACTIVEPAGES parameter of the TUNE command. The Least Recently Used algorithm ignores the timestamp values once pages have been placed in one of the four groups. You can specify how many groups the Least Recently Used algorithm is to form and what timestamp values are to distinguish the groups.

You can specify the following values for the number of seconds in one clock unit: 128, 256, 512, 1024, 2048, 4096, 8192, and 16384. There are three considerations for choosing these values:

- Be careful not to make the time in one clock unit, that is, the time between the timestamps, too long.
- Be careful not to make the time in the total clock too short so that it overlaps (that is, advance through all 16 divisions too fast) too quickly.
- Be sensitive to the Least Recently Used algorithm so that you do not negate the efficiency. Figure 10 lists the number of seconds you specify with the TUNE command and how the seconds translate to time between timestamps and the time in the clock itself.

Seconds in One Clock Unit	Time Between Timestamps	Time in Clock
128 seconds	2.1 minutes	34 minutes (.6 hour)
256 seconds	4.3 minutes	68 minutes (1.1 hours)
512 seconds	8.5 minutes	136 minutes (2.3 hours)
1024 seconds	17.1 minutes	273 minutes (4.6 hours)
2048 seconds	34.1 minutes	546 minutes (9.1 hours)
4096 seconds	68.3 minutes	1092 minutes (18.2 hours)
8192 seconds	136.5 minutes	2185 minutes (36.4 hours)
16384 seconds	273 minutes	4,369 minutes (72.8 hours)

Figure 10. How Least Recently Used Clock Seconds Translate

Now let's assume that we have many pages with each timestamp. When the Least Recently Used algorithm is called to make space available for allocation, the algorithm destages pages according to the groups you specify. For example, you can say first destage all pages with the first four timestamps. Then you specify that all pages with timestamps five and six are to be destaged. Using Figure 11 for an illustration, the pages are destaged as follows: first all pages with timestamps one through four are destaged. If that is not enough to meet the allocatable space requirement, the Least Recently Used algorithm would begin destaging all pages with timestamps five and six.

For a more detailed description of the LRU alogrithm see the publication *IBM 3850 Mass Storage System (MSS) Principles of Operation.*

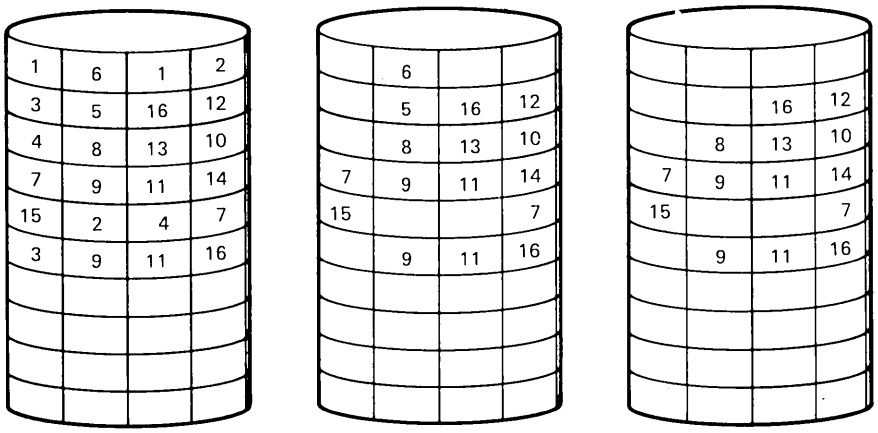


Figure 11. Conceptual Use of LRU Algorithm

The TRACE Reports

Most of the activity within the Mass Storage System takes place under the control of and is maintained by the Mass Storage System itself. Therefore, the CPU has no record of the activities that are being performed in the queues and in the tables that are maintained by the Mass Storage System. Consequently, monitors and traces such as SMF, GTF, MCS, and VS PTI cannot record most of the activity occuring within the Mass Storage System. On these monitors, the Mass Storage System appears only as another I/O device and the communications to the Mass Storage System are recorded; what happens inside the Mass Storage System is not recorded. This is the job of the hardware TRACE function that is activated by the TRACE command. The TRACE command was described earlier in the section "Tracing and Tuning Commands."

The Mass Storage System TRACE report programs use the data that has been gathered from TRACEX and TRACEY and dumped by the DUMP parameter of the TRACE command.

You can select these reports from the data produced by the TRACE command:

- Data Interpretation Report, which shows all the data from TRACEX and TRACEY in readable form.
- Volume Activity Report, which shows mass storage volume activity by volume serial numbers during specific time intervals.
- Staging Adapter Activity Report, which shows the activity during specified time intervals for a designated Staging Adapter.
- Data Recording Device Activity Report, which shows the activity for a specific data recording device during specified time intervals.
- Staging Adapter Distribution Report, which shows the distribution of activity for all Staging Adapters during specific time intervals.
- Data Recording Device Distribution Report, which shows the distribution of activity for all data recording devices during specific time intervals.

Error Recovery Program Support

The Error Recovery Programs within the Mass Storage System try to correct any error conditions that occur. The way the units of the Mass Storage System are connected allow several paths to the same unit. Because of this, all paths to a failing unit are tried before the error condition is passed up to the Mass Storage Control and, eventually, the CPU.

The Mass Storage Control Error Recovery Program:

- Initiates correct recovery actions after analyzing the sense data that is passed up to it from the other Mass Storage System units
- Sends the sense data (with any necessary additions) to the proper CPU
- Unloads the buffered log data from the other Mass Storage System units
- Invokes the Input/Output Supervisor (IOS) to break the Channel Command Word chain to the unit that has the error
- Posts the Unit Check/Device end or Unit Check/Start I/O as required
- Keeps all read/write and data cartridge statistics and sends them to the primary CPU
- Marks the units that are in error as offline or not ready

The CPU Error Recovery Programs handle the sense data from the Mass Storage Control in one of three ways depending on the error indication in the sense data.

- If the sense data only contains status information (for example read/write or cartridge statistics), the information is logged to SYS1.LOGREC and the CPU initiates a retry.
- If the sense data contains a real error (for example, the maximum number of retries for a bus out check is reached), the sense data is logged to SYS1.LOGREC and an indicator is set for a permanent error.
- If the sense data contains an error that would cause a Mass Storage Control swap (for example a permanent equipment check), the CPU attempts to swap the Mass Storage Control with the standby Mass Storage Control. If the swap is successful, the CPU indicates that the host is ready and retries the failing command. If there is not a backup Mass Storage Control, or the backup Mass Storage Control is marked offline, or a swap has been attempted once and failed, the CPU issues a message to the system operator that a swap cannot be made.

Mass Storage System System Data Analyzer

The System Data Analyzer (SDA) is a problem program that uses SYS1.LOGREC information to provide you with statistical data about data cartridge errors and error data about the units that make up the Mass Storage System. The System Data Analyzer produces a series of reports. You can select an individual report or any combination of reports. If you do not specify specific reports, the System Data Analyzer produces all the reports. These reports provide you with information useful in the diagnosis of existing problems and the early detection of error trends.

Because the System Data Analyzer is a problem program, job control language statements are required to initiate the execution of the program and to describe the data sets that are to be used by the program. Full information about the System Data Analyzer is contained in the books *OS/VS1 SYS1.LOGREC Error Recording* and *OS/VS2 System Programming Library; SYS1.LOGREC Error Recording.*

Changes to Existing Programs to Support the Mass Storage System

As you have seen from the descriptions in the preceding section, the programming support for the Mass Storage System is extensive. There are also changes to existing programs to take advantage of the unique features of the Mass Storage System and allow you to use programs that you now have in your computing system. This section describes the changes to those programs that support the Mass Storage System. It does not give a complete description of the program and if you need a complete description, you should get the books that are written specifically for them.

Access Method Services and the Mass Storage System

Three Access Method Services commands are changed: DEFINE, ALTER, and LISTCAT. The only change to these three commands is the addition of parameters to the commands.

The DEFINE Command

The DEFINE command is extended by the addition of three new sets of parameters: VSAM data set staging parameters, VSAM data set destaging parameters, and non-VSAM data set retention period and owner parameters.

The staging parameters are STAGE, BIND, or CYLINDERFAULT and can be specified for any VSAM data set. However, only one of these parameters can be specified for a given data set. These parameters cannot be specified for catalogs; the default for a catalog is always BIND.

The STAGE parameter specifies the staging of data when the data set is opened. This allows optimization of data storage on staging drives according to the Least Recently Used (LRU) algorithm. Data access on staging drives is similar to data access on real drives when there is more storage space available on staging drives than requested data. Data access on staging drives degrades to cylinder fault mode and response time varies with the record being accessed when there is less storage space on staging drives than requested data.

The BIND parameter specifies the staging of the data, when the data set is opened, and the retention of the data on a staging drive until the data is explicity destaged when the data set is closed. Data sets that are staged with the BIND parameter tend to tie up staging space for extended periods; however, record accessing requests for data on the staging drive perform similarly to requests on real drives after the initial staging is complete.

The CYLINDERFAULT parameter specifies the staging of data on an as-needed basis and allows destaging of the data according to the Least Recently Used algorithm. Response time will vary with the record being accessed for most requests since prestaging of the requested data usually will not occur. Selection of this parameter is utilized when prestaging is uneconomical and individual record access response time is not critical.

The destaging parameters are NODESTAGEWAIT or DESTAGEWAIT. You can specify either one of these parameters but not both for a VSAM data set.

The NODESTAGEWAIT parameter specifies that when the data set is closed, destaging of the data will proceed asynchronously with data set closing. Any permanent errors encountered during the destaging process result in operator notification but will not result in any notification to you or your program. Data set closing is similar to data sets on a real drive.

The DESTAGEWAIT parameter requests that when the data set is closed, destaging of the data be completed prior to returning control to your program. The synchronous processing allows your program to be notified when permanent errors are encountered. In addition, you are notified through the use of the write-to-operator (WTO) macro, which is provided for problem determination. Data set closing performance is degraded by a variable amount depending on the amount of data destaged.

You can specify either staging or destaging parameters for data sets that are not on mass storage volumes. The specification results in a catalog entry but does not affect data set processing. However, when the volume is converted to a mass storage volume, the parameters are used.

The non-VSAM data set retention period parameters are TO or FOR. The TO parameter is expressed as a Julian date and the FOR parameter is expressed as the number of days. You can only use one of these parameters for a given data set. Non-VSAM data sets, including Generation Data Group (GDG) entries cataloged in a VSAM catalog, automatically include a creation date. The expiration date and owner identification must be supplied through an OS/VS utility.

The creation date is obtained from the operating-system-maintained date. If you do not specify either expiration date or retention period, the default is zero days retention period. The creation date plus the retention period equals the expiration date.

The retention period attributes are identical to those for VSAM data sets. In OS/VS1 and OS/VS2, they can be specified through the use of the DEFINE NONVSAM command.

The ownership parameter is OWNER. The ownership parameter is the same as for VSAM data sets. In OS/VS2, while operating under the Time Sharing Option Monitor program (TMP), the owner identification defaults to the user identification. Other environments default to an owner identification of NULL.

The ALTER Command

The ALTER command is extended by the addition of the same new parameters that were described under the DEFINE command. Under the ALTER command, however, there aren't any defaults for these parameters. The only way you can change these parameters is to respecify them. Respecification of the retention period results in an expiration date based on the date of alteration instead of the original defined date.

The LISTCAT Command

The LISTCAT command is extended to add selection criteria for listing VSAM and non-VSAM data sets. These criteria use the creation and/or expiration date of each data set and the listing obtained is for only those data sets meeting the criteria. This type of listing aids you in locating expired data sets or potentially unused data sets.

The output of the LISTCAT command is extended for data set and catalog entries to include the mass storage volume attributes. The Mass Storage System information is requested through the use of the ALL fields parameter and is listed under the ATTRIBUTES grouping. Non-VSAM entries include the expiration and creation date when ALL or HISTORY parameters are specified. This information is part of the owner and date grouping and it is in the same format as VSAM entries.

OS/VS JCL and the Mass Storage System

The following job control language parameters require special consideration in the Mass Storage System for new data set requests.

- The UNIT parameter can equal 3330V, an appropriate unit esoteric, or a specific unit address.
- The VOL=SER= parameter or the MSVGP parameter can be used, but not both. The volume serial number of the volume on which the data is to reside is given when VOL=SER= parameter is used. When MSVGP parameter is used, a general-use mass storage volume in the named group that has enough space is used for the data. When you use the MSVGP parameter, the SPACE parameter is optional for any data set organization except ISAM, VSAM, and BPAM. If the SPACE parameter is not coded with the MSVGP parameter, the SPACE parameter defaults to whatever is specified for the group. The MSVGP parameter has a subparameter of DDNAME that enables you to have volume separation between "Master In/Master Out" data sets.
- The SPACE parameter is required when the VOL=SER= parameter is used for new data sets. When you use the MSVGP parameter, SPACE is optional, except for ISAM, VSAM, and BPAM. If you use the MSVGP parameter and don't specify space, you get the amount of space already defined by the group parameters.

Missing Interrupt Handling and the Mass Storage System

As in a system without a Mass Storage System, the Mass Storage Control and virtual units under control of the Mass Storage System can lose interrupts. For a VS1 system the Missing Interrupt Checker (MIC) and for a VS2 system the Missing Interrupt Handler (MIH) have been extended to support checking for missing interrupts from Mass Storage System units. Depending on the type of unit and the type of interrupt the missing interrupt handling support will attempt automatic recovery action, notify the operator with a message, and/or leave the affected job in a cancellable or abendable state.

Depending on the I/O request and the Mass Storage System workload, the time required by the Mass Storage System units to respond with an interrupt will vary. Therefore, to prevent premature checking for interrupts, the missing interrupt handling support does not check for overdue interrupts from Mass Storage System units as often as is done for other units.

The frequency of checking for Mass Storage System units is determined by the user based on the Mass Storage System workload and characteristics.

For more information about missing interrupt handling, see the publications *OS/VS1 Recovery Management Support Logic* or *OS/VS2 System Programming Library: Supervisor.*

SMF and the Mass Storage System

No new System Management Facility (SMF) records are needed to support the Mass Storage System. However, several of the System Management Facility records include an indicator for virtual volumes. Some of the records are modified to contain this indicator and with other records, the indicator is included without any modification.

Service Aids and the Mass Storage System

OS/VS1 and OS/VS2 service aids require no changes to their programs to support the Mass Storage System. All system data sets and Initial Program Load records required by SADMP must be placed on real drives that are either in the Mass Storage System or external to the Mass Storage System, and tape drives must be available for dump output.

IMASPZAP can be used to dump or alter records of the Mass Storage Control tables.

Operator Commands and the Mass Storage System

There are three new operator commands (PURGE, ASSIGN, and DISPLAY 3850) and two existing commands are modified (VARY and HALT).

The PURGE command destages all virtual volumes that were mounted for a specified CPU.

The ASSIGN command is used to assign a primary CPU to receive unsolicited Mass Storage System messages.

The DISPLAY 3850 command displays the current online or offline status of Mass Storage System devices.

New parameters of the VARY command can be used to place a unit within the Mass Storage System online or offline.

New parameters are added to the HALT command to specify the type of shutdown to be executed in the Mass Storage System.

Additional detail for these commands is explained in this book in the section "What Are the System Operator Job Changes?"

Access Methods and the Mass Storage System

The Mass Storage System is supported by VSAM and non-VSAM DASD access methods: QSAM, BSAM, BPAM, BDAM, EXCP, and XDAP. ISAM data sets should be converted to VSAM data sets. Then you can use your old ISAM programs and your converted ISAM data set and the ISAM compatibility interface of VSAM. The compatibility interface translates the ISAM instructions to the appropriate VSAM macros. To use the Mass Storage System for the storage and accessing of data, the user programs must use the standard access methods or use EXCP using IBM-supplied OPEN/CLOSE/EOV.

Access methods and EXCP users who open physical sequential data sets for output must be aware that staging is done up to the cylinder containing the end of file as specified by the track balance field in the format 1 DSCB.

User programs that have no time dependencies and work properly with 3330 Model 1 Disk Storage will work properly without change when using staging drives. Existing DASD job control language requires changes in the UNIT parameter to direct data to the Mass Storage System. The other job control language parameters are compatible.

Existing tape job control language requires changes in the UNIT parameter, consideration for tape oriented parameters, and changes required for a DASD environment. An example of the changes required is the addition of the SPACE parameter. Both tape and DASD job control language require changes to take advantage of the Mass Storage Volume Control functions.

The data management components issue requests to the Mass Storage System Communicator program for the mounting and demounting of volumes. The data management components verify that the correct volumes are mounted, request the allocation of staging space, and if necessary, request that data be staged. The volume manipulation and data set acquisition is accomplished without any changes to the data management macros. The user interface to the data management components has not changed.

The current mount and demount logic in the data management routines is not used for handling mass storage volumes. Volume requests involving mass storage volumes are directed to the Mass Storage System Communicator rather than the system operator. Messages involving mounting and demounting mass storage volumes are not printed on the operator's console by any of the data management routines. The messages are sent to the Journal data set and/or a terminal designated by the space manager just for these messages.

Space acquisition and data staging when the data set is opened are provided for all current access methods except ISAM. ISAM data sets are only staged after the operating system has tried to access the data; this is referred to as "cylinder-fault mode". ISAM data sets can be converted to VSAM data sets and accessed through the use of the VSAM compatibility interface.

Non-VSAM CLOSE or any of the access methods have not changed to support the Mass Storage System.

All existing 3330 Model 1 Disk Storage channel programs run in the Mass Storage System without modification.

All data management routines (except VSAM) request an abnormal termination in the event of a Mass Storage System failure. A non-zero return code from the Mass Storage System Communicator indicates a subsystem detected error. However, it is important to note that staging errors can only be detected when the user accesses his data set. Such errors appear as permanent I/O errors. Destaging errors are detected by the Mass Storage System only when a volume is demounted or cylinders destaged.

VSAM and the Mass Storage System

Virtual Storage Access Method (VSAM) is a DASD access method that operates on relocate versions of System/370 with OS/VS. VSAM supports DASD drives in a device independent manner and therefore the virtual volumes of the Mass Storage System are automatically supported because of their DASD characteristics. Mass Storage System features beyond those of virtual volumes require additional support. These new features include data staging and destaging and volume manipulation.

The VSAM interface for data set open/close/extension is unchanged for Mass Storage System support. The effect of using this interface is unique to the Mass Storage System and is dependent on the VSAM data set options selected through Access Method Services. The following description describes the direct results of using these current interfaces in terms of the Access Method Services external interfaces specified and the JCL parameters selected.

VSAM Data Set Open

VSAM OPEN performs its functions regardless of the application program interface used to invoke data set open. The OPEN functions, which are changed or added for the Mass Storage System, include volume mounting or verification, data staging, and problem determination.

Volume mounting is basically a residual function that is performed when the job scheduler has been directed to defer mounting until your program needs access to the data set. When deferred mount is specified for a mass storage volume, OPEN directs a mount request to the Mass Storage Control instead of to the system operator as with real DASD volumes. Volume verification is performed as it is for any DASD volume regardless of the mechanisms used to mount the volume. Since volume verification includes the reading of the volume label, OPEN does not return control to your program until all volumes have been mounted and verified. It is suggested that the Volume Table of Contents be on cylinder 0. Any other cylinder location requires additional staging.

VSAM Data Set Close

VSAM CLOSE performs data set extension and catalog management functions for data sets that reside on mass storage volumes. These functions provide various data destaging operations. Destaging operations are selected by the data set attributes established with Access Method Services commands.

VSAM Data Set Extension

VSAM EOV performs some of the functions of VSAM OPEN and VSAM CLOSE. These functions, which are changed or added for the Mass Storage System, include volume mounting/demounting, data staging/destaging, and problem determination. The End of Volume (EOV) functions are invoked automatically by VSAM Record Management.

VSAM Catalog and Catalog Management

The VSAM master catalog must reside on real DASD; it cannot reside on a mass storage volume. VSAM user catalogs, however, can reside on mass storage volumes. The use of these user catalogs requires neither change to VSAM catalog management nor additional user specification. No check is made during VSAM master catalog or user catalog definition for mass storage volume residence.

Utilities and the Mass Storage System

The OS/VS utilities IEHATLAS, IBCDMPRS, and IBCDASDI should not be used for staging packs.

IEHDASDR is modified to format Mass Storage System staging packs by assigning the alternate track area to cylinder 409 - 410 for a 3336 Model 1 Disk Pack and cylinder 809 - 814 for a 3336 Model 11 Disk Pack.

A new keyword (MSS) on the IEHDASDR offline ANALYZE control statement is used to indicate that a staging pack is to be formatted.

You can use OS/VS utilities to gain direct access to the Mass Storage Control tables. Specifically, you can use:

IEBGENER to dump or restore or copy Mass Storage Control tables by using the table's data set names,

IEBCOMPR to compare primary or secondary Mass Storage Control tables by using the table's data set names,

IEHDASDR to dump and restore the Mass Storage Control tables and to print selected areas of the tables, and

IEHPROGM to verify the password protection for the Mass Storage Control tables.

JES3 and the Mass Storage System

The JES3 program verifies every non-specific volume selection. This support is available only under an OS/VS2 MVS system.

For more information on JES3 see the publication, *OS/VS2 MVS JES3 Mass Storage System Selectable Unit System Information.*

System Generation and the Mass Storage System

The following changes have been made to System Generation (SYSGEN) to accommodate the Mass Storage System:

- IODEVICE supports the Mass Storage Control and 3330V as new devices.
- UNITNAME cards describe real and virtual drives that are in the Mass Storage System.

The Mass Storage Control Table Create program punches IODEVICE and UNITNAME cards.

- IODEVICE macro has a new parameter to indicate a virtual Unit Control Block (UCB) (UNIT=3330V).

Data Base/Data Communication Programs and the Mass Storage System

Data Base/Data Communication (DB/DC) programs that use VSAM and non-VSAM DASD access methods (BSAM, QSAM, BPAM, BDAM, and XDAP), or EXCP, and IBM supplied OPEN/CLOSE/EOV can operate in a computing system containing the Mass Storage System with very little if any modification. What modifications that have to be made are peculiar to the particular Data Base/Data Communication program you may be using.

The Mass Storage System is intended primarily for batch and certain response insensitive online environments. It is not intended for response oriented, interactive Data Base/Data Communication environments where having less real DASD space than needed degrades the transaction response time. The Mass Storage System is further not intended for permanent storage for Data Base/Data Communication programs. Program loading is itself a significant performance requirement and should not be degraded by Mass Storage System access times.

This section describes some of the things you should consider when two particular DB/DC programs are used in a system that contains the Mass Storage System.

IMS/VS and CICS/VS

If you are already using either of the IBM Data Base/Data Communication program products; Information Management System (IMS/VS) or Customer Information Control System (CICS/VS), there are special considerations you must give to planning for a Mass Storage System. The presence of the Mass Storage System can affect your Data Base/Data Communication activity whether or not the Mass Storage System actually houses the Data Base/Data Communication data bases.

Time Sharing Option

Your Time Sharing Option (TSO) programs can operate with the Mass Storage System without any modification of your existing Time Sharing Option data. Foreground jobs still execute in the same manner as they do in a system that does not contain the Mass Storage System, provided that data sets are on real volumes. However, when archived data sets are used, these data sets can be on mass storage volumes.

Background jobs will be handled the same as in a system that does not contain the Mass Storage System. When the background job is finished with the data, the data is archived in the Mass Storage System. This means that you must have real drives to be used by Time Sharing Option data and that in the transfer of data to and from the Mass Storage System and Time Sharing Option drives, the CPU channels are used.

TSO Archive Procedure Prerequisite

You can establish a TSO CLIST containing the commands necessary to submit a job to perform the archive or retrieve function through the use of a data set copy. A familiarity with the following OS/VS2 Time Sharing Option commands and associated function, OS/VS2 JCL, and utilities is required:

- EXEC command, to execute a command procedure.
- EDIT command.
- SUBMIT command, as a subcommand of the EDIT command.
- LISTDS/LISTCAT/DELETE commands, for identification of archived data sets and to clean up working or current storage.
- IEBCOPY, which is a system data set utility for partitioned data set copy.

These publications provide information on Time Sharing Option and OS/VS utilities: *OS/VS2 TSO Command Language Reference, OS/VS2 TSO Terminal Users Guide, OS/VS2 JCL,* and *OS/VS Utilities.*

Setting Up Archive Procedures

The use of an archive procedure requires the creation of a command procedure data set using the Time Sharing Option Editor. This procedure is ultimately executed through the use of the EXEC command, causing (under EXEC control) an EDIT and a SUBMIT of an OS/VS JOB to perform the archive copying function when the background job is executed. You can get a notification of job completion by specifying the NOTIFY keyword on your SUBMIT command.

You must decide on the the following parameters that are substitutable in the CLIST through the use of a PROC statement.

- Data Set Naming. You must establish a naming convention using the same or a similar naming convention normally used for your Time Sharing Option data (such as, userid.TEXTA.TEXT). The from and to data sets can be specified at the time that the EXEC command is issued.
- Volumes. In copying from and to the archive on mass storage volumes, the volume serial number or MSVGP parameter only has to be specified for the allocation of new data sets. All old data sets are cataloged to the Master or Private catalogs.

The input statements for your CLIST should consist of:

- The PROC statement
- The use of CLIST SET, GLOBAL, GO TO, and SKIP statements and READ or WRITE statements to generate the correct job control language and prompt and/or notify the Time Sharing Option terminal user during CLIST execution
- An EDIT of the new data set containing the JCL statements.

- The job control language statements entered in EDIT mode. As an example,

  ```
  ''//STEP  EXEC  PGM=IEBCOPY''
  ```

  can be used to specify job control language for the data set copy utility or other copy programs. The substitution for data set names, volume serials, MSVGP, and other chosen variables should be noted. For example,

  ```
  ''//DDIN  DD  DSN=&FROMDS,DISP=OLD''
  ```

- A SUBMIT statement to cause the job being edited to be submitted to the batch processor when the command procedure is executed
- Two END commands to get out of EDIT mode and to terminate the command procedure

The Time Sharing Option OUTPUT command can optionally be used to print the job control language and messages of the job at the user's terminal when the job has completed.

How Do Existing Jobs Change?

In order for you to receive maximum benefits from the Mass Storage System, there are some changes and added responsibility for some of your people. These people are: the system programmer, the operator, the space manager (a new responsibility), and the application programmer. This section describes the added responsibilities for the system programmer, the operator, and the application programmer.

What Are the System Programmer Job Changes?

The major change to the system programmer activity is the introduction of two new device types: the Mass Storage Control and the staging drives (3330Vs). Another consideration for the system programmer is the Mass Storage Control tables. Any hardware configuration change, either to the host CPU or CPUs or to the arrangement of the internal I/O units associated with the Mass Storage System, requires an update to the Mass Storage Control's configuration tables.

When the Mass Storage Control Table Create program is run, during installation time or during reconfiguration of the Mass Storage System, IODEVICE and UNITNAME punched cards are produced for direct input to Stage I of SYSGEN. The IODEVICE cards represent the drives and Mass Storage Control of each CPU attached to the Mass Storage System. The UNITNAME cards, one or more for each staging drive group, reflect all staging drive unit addresses associated with that staging drive group on a CPU basis, and provide an esoteric group name for each staging drive group.

You should assign a hard copy device for Mass Storage System-only information. By so doing, you will have a chronological listing of Mass Storage System activity available for analysis for system maintenance and data management. The messages that should be routed to this device are system messages issued by either the Mass Storage System Communicator or the ERPs.

In a multi-host environment where CPUs cannot share a hard copy device, assign the device to one CPU and designate that CPU as primary. All services requiring cartridge exits should be run from the primary CPU. For more information about the requirements for user-written exit routines, see *IBM 3850 Mass Storage System (MSS) Installation Guide.*

There are seven commands to help you recover the Mass Storage System. These commands are: AUDITMSS, CHECKMSS, COMPARET, COPYT, DUMPMSS, NULLIFYC, and SWAPT. They will help recover the Mass Storage System from the following types of problems: I/O error on a Mass Storage Control tables pack, failures occurring when cartridges are retrieved or returned to their cells in the Mass Storage Facility, suspected software failures, and destage errors occurring during execution of the order to copy the Mass Storage Control tables to a mass storage volume. For more information about these commands, see *OS/VS Mass Storage System (MSS) Services for Recovery.*

There is no special System Management Facilities (SMF) support required for the Mass Storage System. The existing records include data reflecting 3330V rather than 3330. In addition to the System Management Facilities, there is the TRACE facility that can be turned on or off by the TRACE command and a TUNE command is provided whereby clock values affecting the performance of the Mass Storage Control may be altered and displayed. By modifying the parameters of the TUNE command, you are able to control space reclamation for each staging drive group based on your ability to direct specific processing applications to a partitioned subset of the Mass Storage System staging drives or a modification based on your specific shift requirements.

The system data sets supported on a mass storage volume are the VSAM user catalog, OS CVOLs, and the usercat.MSVI data set.

The VSAM Master Catalog and the OS/VS1 or OS/VS2 System Catalog must not reside on a mass storage volume. Other system data sets that must not be allocated to a mass storage volume fall into two categories: (1) programs that must be initial program loaded or (2) the data sets that must be accessed prior to completion of system initialization. These two catagories of system data sets must reside on a real drive within the Mass Storage System or on a real DASD that is outside the control of the Mass Storage System.

For those system data sets that are to be placed on mass storage volumes, the routines that initialize the data sets have been modified to call the Mass Storage System Communicator for orders of MOUNT, ACQUIRE, and DEMOUNT.

These Scheduler system data sets must always be assigned to a real volume on a real drive:

INITIATOR SWADS
SYS1.PROCLIB
SYS1.SYSJOBQX
SYS1.SYSPOOL
SYS1.SYSWADS

These Supervisor system data sets must always be assigned to a real volume on a real drive:

IPL
SYSCTLG
SYS1.BRODCAST
SYS1.DSSVM
SYS1.DUMP
SYS1.IMAGELIB
SYS1.LINKLIB
SYS1.LOGREC
SYS1.MANX
SYS1.MANY
SYS1.NUCLEUS
SYS1.PAGE
SYS1.PARMLIB
SYS1.SVCLIB
SYS1.UADS

The LINKLIB concatenated data sets (not cataloged on LNKLST00) can optionally be assigned to mass storage volumes. This approach represents a potential performance degradation and the degree of degradation is dependent largely on the data set size and activity.

The SYS1.CMDLIB system data set must always be assigned to a real volume on a real drive.

The SYS1.MACLIB data set can optionally be assigned to mass storage volumes after SYSGEN. Here again, there is a potential for performance degradation.

These system data sets can optionally be assigned to mass storage volumes after SYSGEN:

SYS1.ACCT
SYS1.RMTMAC
SYS1.TELCMLIB

Any user-defined sort and compiler system data sets can experience performance degradation when they are assigned to a mass storage volume.

What Are the System Operator Job Changes?

Your job, as a system operator, is almost the same as it was without the Mass Storage System. However, there are some activities that are impacted by or unique to a system containing the Mass Storage System.

Initial Program Load of the System

Although mass storage volumes normally can be treated as real 3330 Disk Storage packs, the ability to Initial Program Load the system directly from mass storage volumes is not supported. Since the data cartridges are not directly addressable, their data must be moved first to a staging drive. To move the data from data cartridges to a staging drive requires more Mass Storage System assistance than is available during the system Initial Program Load. You are, therefore, limited to a system Initial Program Load from real Disk Storage packs on real drives that require no translation by the Mass Storage Control.

Another action that is required by you during Initial Program Load is to assign a primary CPU if the Mass Storage System is operating in a multi-CPU environment. During normal operation of the Mass Storage System, unsolicited information is generated and the Mass Storage Control passes this information on to the primary CPU. This unsolicited information usually concerns the Mass Storage System as a whole and is not the result of specific CPU activity, so the Mass Storage Control can only direct it to the primary CPU.

Inserting Data Cartridges

The process of entering data cartridges into the Mass Storage Facility will be done rather infrequently after the Mass Storage Facility is initially loaded. The anticipated times are:

- When more data cartridges are needed in the Mass Storage Facility
- When a mass storage volume that is stored outside the Mass Storage Facility is needed
- When another Mass Storage System's data is needed for a specific job, although mass storage volumes are not intended to be used as interchange media
- To replace data cartridges that have been removed because of failing media

This action of entering data cartridges into the Mass Storage Facility is independent of the CPU; the movement of a data cartridge from the cartridge access station to a cell in the Mass Storage Facility is accomplished totally by the Mass Storage System hardware. However, the Mass Storage Control notifies the primary CPU of this data cartridge movement and a message is printed on your console stating some characteristics of the entered data cartridge. The characteristics include the data cartridge serial number if the data cartridge is not part of a volume. If the data cartridge is part of a volume, the volume serial number is in the message and whether the data cartridge is the first or second data cartridge of the volume.

If the data cartridge is part of a mass storage volume, the data cartridge identification of the first data cartridge and the location of the data cartridge that is being entered is placed in the Transient Volume List. Data cartridges placed on this list are not eligible for mounting by the host CPU because the Volume Identification (VOLID) of the data cartridge being entered may be a duplicate of a mass storage volume already resident in the Mass Storage Facility. Since mounting the mass storage volumes is done by volume name, a job could acquire the wrong data.

Execution of the ADDV service command is required to move the entered mass storage volume to the Volume Inventory List.

The Mass Storage Volume Control functions must not be disabled when data cartridges that are not part of a volume are entered into the Mass Storage Facility. If data cartridges are entered when the Inventory data set is disabled, you are notified that the Inventory data set is out of step with the Mass Storage Control because of the entry.

Ejecting Data Cartridges

The ability to eject data cartridges from the Mass Storage Facility is controlled by the EJECTC, EJECTV, STOREV, COPYV, and REPLACEC service commands. The EJECTC and REPLACEC service commands provide the ability to eject a single scratch data cartridge. The EJECTV, STOREV, and COPYV service commands eject both data cartridges of a mass storage volume. When any of these service commands finishes, a listing is produced that indicates the data cartridges or mass storage volumes that were ejected. This listing should be retained with the data cartridges to assist in identifying them while they are physically out of the Mass Storage Facility.

The Mass Storage Control deletes all references in its tables to mass storage volumes and data cartridges when they are ejected. However, the Inventory data set optionally maintains information on volumes outside of the Mass Storage Facility including the shelf location of the volume or data cartridge if the shelf location is specified at the time of removal.

Valid data can only be removed from the Mass Storage Facility in units of mass storage volumes, which always consist of a pair of data cartridges. Single data cartridges that are not part of a volume and are ejected contain no usable data. Since data cartridges are identified by a visible data cartridge serial number, those data cartridges belonging to a mass storage volume can only be identified by the listing produced or by a report from the Inventory data set. It is very important that the two data cartridges of the mass storage volume be treated as a unit.

Mass Storage System Failures

If a CPU fails, certain activites are required of you that are unique to the Mass Storage System. If the failing CPU has been designated as the primary CPU and the environment of the Mass Storage System is multi-CPU, the primary CPU designation must be reassigned to another CPU in order to permit the Mass Storage Control-to-CPU communication for unsolicited messages.

When a CPU fails that has been communicating with the Mass Storage System, it is highly probable that some of the Mass Storage System's virtual volumes have been staged for the failed CPU. Before other CPUs can use the virtual volumes, a PURGE command must be issued from another CPU. This destages all virtual volumes the Mass Storage System had staged to the failing CPU.

Failures within the Mass Storage System also require unique action on your part. These failures are described for each individual unit.

If the failing unit is a Mass Storage Control, and the error condition necessitates a swap of Mass Storage Controls, the CPU Mass Storage Control Error Recovery Program (ERP) passes the error to the Error Recovery Program Swap Modules. Error conditions such as program check, protection check, or command reject do not cause a swap. The Error Recovery Program Swap Modules examine the Mass Storage System Communicator control block for an alternate Mass Storage Control, and if one is available, a message is printed on the console of the primary CPU indicating that a swap of Mass Storage Controls is going to be attempted. The Unit Control Block (UCB) contents are effectively exchanged, the failing Mass Storage Control is marked offline, and an offline message for the failing Mass Storage Control Unit Control Block is printed on the console of the primary CPU. The Error Recovery Program Swap modules issue commands to switch to the backup Mass Storage Control, initialize the new Mass Storage Control, indicate that the Mass Storage System is ready, and re-issue the orginal failing command. A message is printed on the console of the primary CPU indicating that the swap to the alternate Mass Storage Control was either successful or unsuccessful.

If the alternate Mass Storage Control is not available (either does not exist or is offline) or if the swap was attempted but was not successful, a message is printed on the console of the primary CPU indicating that a swap is not possible. The Mass Storage Control Swap modules set the "not ready" bit in the failing Mass Storage Control Unit Control Block. Repairs and/or Initial Microprogram Load can now be done on the Mass Storage Control.

If the failing unit is a Staging Adapter, the results are essentially the same as today's failing 3830 Storage Control unit if the Staging Adapter is successfully varied off.

If the failure occurs in a 3333 Disk Control, no processing on the drives that are attached to that control or recovery for the failing control can occur until the fault is corrected.

If the failure occurs on a drive, you can move both the disk pack and the address plug to an available free drive that is in the same staging drive group. In the event a pack or address plug is changed, the Mass Storage Control immediately compares the volume label and drive address. A mismatch will exist if you haven't changed both the disk pack and the address plug. The Mass Storage Control prohibits any further access to that drive until you correct the mismatch.

If the failing unit is a data recording device and the Mass Storage Control is able to retrieve all data cartridges from that data recording device, the Mass Storage Control attempts to mount those data cartridges on a different data recording device and continue processing.

If the failing unit is an accessor, the Mass Storage Facility causes the failing accessor to be moved out of the way and its duties are assumed by the remaining accessor.

You are notified of the failure, and if possible, the steps you should take to recover. Extensive error analysis support is provided to assist both you and maintenance personnel in error recovery.

Mass Storage Volume Control Data Set Recovery

For data set recovery, the Mass Storage Volume Control functions require two data sets:

- The current Journal data set, usercat.MSVCJRNL. It is an EXCP data set allocated prior to the first Initial Program Load after System Generation. Although, the Mass Storage Volume Control functions provide the ability to automatically record critical Mass Storage Volume Control operations in this journal, the space manager is responsible for coordinating levels of backups and journals.
- A backup Inventory data set. It is a version of the usercat.MSVI data set that is created by the space manager through the use of the Access Method Services EXPORT or REPRO commands.

These two data sets, in combination with specific restoration procedures, permit Mass Storage Volume Control functions to provide data set recovery for the Inventory data set.

The backup and recovery procedures in a multi-CPU environment require more control than required in a single host environment. Special action must be taken so that the data set being recovered is taken offline from all systems prior to being restored. This will ensure that one system is not issuing I/O against the data set while another system is attempting the recovery operation. Toward this consideration, Mass Storage Volume Control functions provide a DISABLE function that allows an installation to temporarily disable the Mass Storage Volume Control functions so that the Inventory data set can be restored, and an ENABLE function to then enable Mass Storage Volume Control functions without the need to de-activate and then re-activate the Mass Storage System by another Initial Microprogram Load for all systems.

Mass Storage Volume Inventory Data Set Backup Procedure

The procedure to create a backup for the Mass Storage Volume Inventory data set is to: disable the Mass Storage Volume Control functions, use the Access Method Services EXPORT or REPRO commands to create a backup of usercat.MSVI, and then enable Mass Storage Volume Control functions. This procedure is accomplished through the use of Mass Storage Volume Control functions, which are explained in the section "Mass Storage Volume Control Recovery and Maintenance Functions." The first and last step in this procedure depend on the Mass Storage System configuration at the time the backup is created. When the Mass Storage Volume Control functions are disabled, the Journal data set should be nulled to keep the backup Inventory data set and the Journal data set in step.

If the Mass Storage Volume Control data sets reside on real drives, this procedure can be executed during a period when the Mass Storage System is inactive on all CPUs. Under these conditions, backup procedures can be executed without disabling the Mass Storage Volume Control functions.

If the Mass Storage Volume Control data sets reside on staging drives (virtual DASD), this procedure must be executed when all CPUs either have their Mass Storage Volume Control functions disabled or have the Mass Storage System inactive to the CPU.

Mass Storage System Operator Messages

There are several messages that are generated by the Mass Storage System that require unique actions on your part. An example is the message that notifies you when the TRACE recording area has been switched. If you want the data that has been recorded, you must move the data to a mass storage volume before the recording areas are switched again. Otherwise, the recorded data in the area is lost. These messages and your actions are documented in *OS/VS Message Library* for OS/VS1 and OS/VS2 System Messages.

Mass Storage System Operator Commands

The following commands are specifically provided for you to control and change the Mass Storage System operation. There are procedures that must be followed when using these commands. Particularly when the commands are used in a multi-CPU environment. These procedures are described in *Operator's Library: IBM 3850 Mass Storage System (MSS) Under OS/VS.*

VARY Mass Storage System Units

You can use the VARY command to place a Mass Storage System device online or offline to the Mass Storage Control. The Mass Storage System devices that do not have a Unit Control Block are identified to the host system by a Mass Storage System Identification in place of the unit address in the command. A new parameter "S" identifies the unit address as a Mass Storage System Identification (SSID). The Mass Storage System Identification consists of three hexadecimal characters. A unit is varied on or offline through the use of the Mass Storage System Identification. Each device in a Mass Storage System must be identified during installation with a Mass Storage System Identification.

The unit address of the Mass Storage Control, which is represented in the host system by a Unit Control Block, must also be identified by the parameter "S" when it is specified in the VARY command.

A VARY range ability exists whereby you, by specifying a low unit address and a high unit address, may vary on or off all the units within the range of the two addresses including the specified low and high addresses. This ability reduces the number of commands that must be entered when a number of units must be varied off for repair or on. For example, when you are working on a Staging Adapter, you may wish to vary off all the drives attached to that Staging Adapter and later vary them all back on. The VARY command is also used to vary a convertible drive offline to change its status, then vary it back online.

The Mass Storage System units normally are varied off and on to accomplish maintenance on a particular unit. Staging drives may be varied off and on to control the performance of the Mass Storage System during the periods of high and low activity.

The HALT command

You can shutdown the Mass Storage System during extended periods of inactivity. New parameters on the HALT command are used to specify the type of shutdown to be executed in the Mass Storage System. A complete description of the HALT command isn't given here; only the Mass Storage System parameters are described.

The SNAP parameter, specified in the shutdown of a CPU that is not the primary CPU in a multi-CPU environment, disconnects the CPU from the Mass Storage Control. The connection is not available to that CPU until its operating system is initial program loaded again. However, the specification of the LONG option from a non-primary CPU is an error.

The SNAP and LONG options, used when shutting down the primary CPU after all non-primary CPUs have been shut down, results in the following:

- The SNAP option is an immediate shutdown. All stage/destage operations currently in progress are allowed to complete and all Data Cartridges are returned to their cells in the Mass Storage Facility. When the Mass Storage Control notifies you that the shut down is complete, power can be shut off. For the SNAP option to complete takes a relatively short time as compared to the LONG option.
- The LONG option is a shutdown for reconfiguration of the Mass Storage System. The LONG option causes all scheduled stage/destage requests to complete and completely shuts down the Mass Storage System. All written cylinders on staging drives are destaged and all volumes are demounted. All data cartridges are returned to their cells in the Mass Storage Facility. The LONG option can take a relatively long time to complete depending on the activity pending in the Mass Storage System. You are notified when the shutdown is complete.

The device end is not returned to the CPU until the required Mass Storage Control processing has been completed.

You should give the HALT S command with either the SNAP or LONG parameters when powering down the Mass Storage System. A new parameter "S" identifies the unit address as a Mass Storage System Identification (SSID). If you don't give the HALT S command or the command is not performed, the following results occur:

- If you don't give the HALT S command and the Initial Program Load is performed on the CPU without the Mass Storage System, the Mass Storage Control connection to the CPU can present unrecognizable interrupts that are ignored by the System Control Program (SCP).
- If the HALT S command is not given and the power is turned off on the Mass Storage Control, the work currently in process is not completed and the work queued in the Mass Storage Control is lost. (During Initial Microprogram Load, the Mass Storage Control is returned with only stage and destage requests maintained. VARY, PURGE, and other requests are lost.) Messages to the Mass Storage Control from the Mass Storage Facility are lost. When the Initial Microprogram Load is performed on the Mass Storage Control following this situation, the Mass Storage Control returns all data cartridges to their cell locations, rebuilds the Staging Adapter tables including a marking of all Virtual Volumes, which had been staged when power was cut off, as valid and mountable. If an alternate Mass Storage Control is in the Mass Storage System, it takes over automatically from the powered down Mass Storage Control.

- If the HALT S command is not given and the host CPU is powered off and the Mass Storage Control is not powered off, the work queued in the Mass Storage Control is completed and the Mass Storage Control eventually ends in an idling situation. Messages to the CPU are stored on the Mass Storage Control table pack, staged data remains staged, and data cartridges remain in their last working station.

The ASSIGN Command

You can use the ASSIGN command to assign a primary CPU to receive the unsolicited Mass Storage System messages or to reassign another CPU as primary when the initial primary CPU is down. This command is only effective when multi-CPUs are sharing the Mass Storage System.

The PURGE Command

You can use the PURGE command to demount all mass storage volumes that are mounted for a specific CPU. This command is used to release all the resources of a CPU in a multi-CPU environment when that CPU has gone down.

The DISPLAY 3850 Command

The DISPLAY 3850 command provides a way for you to display the current status of Mass Storage System devices. This command displays the online or offline status of Mass Storage System units by their subsystem identification (SSID). The types of devices that are part of the Mass Storage System and referenced by subsystem identifications are staging drives, the Mass Storage Facility, accessors, data recording devices, data recording controls, and Staging Adapters. The subsystem identifications are displayed rather than the real device addresses because any requests to modify device status is specified to the system using the subsystem identification. Only subsystem identifications that were created by the Mass Storage Control Table Create program are displayed.

How Must the Application Programmer's Job Change?

To you, the application programmer, Mass Storage Volume Control functions mean having to know less about DASD volumes and the job control language than you would have to know in a DASD environment. It means less job control language impact on you when you are preparing your job stream. It leaves space management of the volumes, on which you allocate space, to the space manager and leaves you to concentrate on the application area.

With Mass Storage Volume Control functions and the use of groups, you need only specify the data set name, UNIT parameter, group, and disposition parameters for non-specific non-VSAM data sets (DD cards) that you wish to have created. You need not specify space. You are assigned to a group by the space manager after you have specified the characteristics of the data set you want created. These characteristics include the size and potential size of the data set. You need not know about changed characteristics of the group or change your job control language. The space manager can alter the characteristics of a group and have all subsequently created non-specific non-VSAM data sets conform to the new characteristics.

Mass Storage Volume Control functions assist you during the initial conversion of data into the Mass Storage System. The space manager can define a group to be used for conversion. Space values in this group can be set with the primary space equal to the capacity of a 3336 Model 1 Disk Pack volume less the Volume Table of Contents, and secondary space can be equal to the 3336 Model 1 Disk Pack volume less Volume Table of Contents also. This ensures that for nonspecific requests, only one data set will be allocated to a volume in the group and allows you to put as much data as you want per data set so long as you specify an adequate volume count in your DD statement for your new data set. The space manager can also specify the "release unused space" option for the conversion group to cause the unused space to be freed at the time the data set is closed. The space manager can then list the Volume Table of Contents on the volumes to determine the size of each converted data set. The data set can then be copied to an appropriate mass storage volume group, or its volumes can be moved to such a group.

Mass Storage Volume Control functions provide a means for you to get out of the volume control and management business and require minor job control language impact to you if you are a tape or DASD user.

OS/VS JCL Procedures for Using Mass Storage Volume Groups

When you, the application programmer, are writing job control language for jobs that create or access non-VSAM data sets that reside in the Mass Storage System, the following rules must be used. Abnormal termination can occur when these rules are not followed. At other times, Mass Storage System performance is degraded.

- If an old multi-volume data set resides in mass storage volume groups, you should specify "parallel mount" in the UNIT parameter of the DD statement for the data set, or you should specify a unit count equal to the number of volumes that contain the data set in the UNIT parameter if non-specific requests exist in the same job step.

  In OS/VS1, all mass storage volumes of multi-volume data sets must be mounted before any mounts for nonspecific requests on that group are made. This is required so that unit conflicts do not occur during execution of the job step. If all volumes are not mounted prior to nonspecific request processing, Mass Storage Volume Control functions can select one of the volumes containing the data set. In this case, your program abnormally terminates when it comes time to mount the volume, because Mass Storage Volume Control functions already have it mounted on another unit.

  In OS/VS2, the situation generated by multi-volume data sets is not so severe, but here too, enough units should be specified to allow all volumes to be mounted. If all volumes are not mounted, system performance is degraded by having to recycle for another mass storage volume when allocation determines that Mass Storage Volume Control functions have selected a volume that allocation may need later in the job step.

- DEFER mounts should not be specified for volumes belonging to a mass storage volume group if there are new data sets in that job step using the same group.

  In OS/VS1, this causes another unit conflict problem. The DEFER mount request is abended when its mount is issued by OPEN if Mass Storage Volume Control functions have selected the volume for a nonspecific request on another unit.

  In OS/VS2, system performance is degraded by having to recycle for another volume when allocation determines Mass Storage Volume Control functions have selected a volume it needs later in the job step.

- To extend multi-volume data sets to another mass storage volume, the unit count in the UNIT parameter must be less than the volume count in the VOLUME parameter. This is required so that one of the units for the data set is allocated non-sharable. A non-sharable unit is required so that End-of-Volume can demount one of the data set's volumes and mount another volume for the data set extension. If End-of-Volume is not able to demount a volume, your program abends.

- All volumes containing a part of a multi-volume data set should be specified in the DD statement (through the use of a catalog reference or a Volume Serial List) of the data set if the data set can be extended. This is required to prevent Mass Storage Volume Control functions from selecting a volume that already contains part of the data set for End-of-Volume. If End-of-Volume finds that the volume the Mass Storage Volume Control functions selected already contains part of the data set, your program abends.

- In OS/VS2, you should specify PRIVATE in the VOLUME= parameter on specific-request DD statements if the volume belongs to a mass storage volume group that is to be used only by the owners or users of that particular group of volumes. The default for the volume is PUBLIC REMOVABLE if the specific request does not indicate PRIVATE.

  PUBLIC REMOVABLE volumes are going to be used by the operating system for non-specific temporary data set requests when the group parameter is not specified. Because of this use, volume space is no longer group controlled; nor are volumes group controlled because they are going to remain mounted so long as the system continues to use them for temporary data sets. PUBLIC REMOVABLE volumes are not going to be demounted until the system needs the unit. This type of use ties up space and volumes so that requests on the mass storage volume group may not be satisfied.

- Mass Storage Volume Control functions always select general-use mass storage volumes for allocation as primary volumes (at least enough space for one primary extent, at a minimum). Therefore, only one device should be requested through the use of job control language for a new, non-specific, data set whose volumes are selected by Mass Storage Volume Control functions so that only one volume is requested at allocation time (the primary mass storage volume).

  For example, consider the possible consequences if two mass storage volumes are requested during allocation and space is as follows:

  Primary = 100 cylinders
  Secondary = 20 cylinders

Allocation requests Mass Storage Volume Control functions to select two mass storage volumes that have enough space for the primary space size (100 cylinders). Mass Storage Volume Control functions choose two mass storage volumes that at a minimum each have enough space for one primary extent. If the Mass Storage Volume Control functions cannot find two such mass storage volumes, the job abends. Whereas, given the above space requirement and one volume requested during allocation, Mass Storage Volume Control functions could have been successful in finding one primary volume (on the basis of primary = 100 cylinders) during allocation and later another volume (on the basis of secondary = 20 cylinders) at End-of-Volume.

For the next example, space is as follows:

Primary = 100 cylinders
Secondary = 200 cylinders

Allocation requests Mass Storage Volume Control functions to select two mass storage volumes as primary volumes. Mass Storage Volume Control functions choose two volumes that at a minimum each have enough space for one primary extent. Mass Storage Volume Control functions can successfully find two such volumes, but End-of-Volume cannot always be successful in acquiring a secondary extent (200 cylinders) on the second of these volumes, because it was chosen on the basis of a minimum space for one primary extent (100 cylinders).

- As an application programmer, you should use the system catalog facilities for data sets residing in the Mass Storage System. Through the use of the catalog facilities, the Primary and Secondary space problem is minimized. This implies that all data sets have unique names. New data sets should be cataloged when they are created. Any time the data sets are processed such that they can be extended to other volumes, the catalog should be updated. To reference any existing data set, it should be located through the use of the catalog.
- Data sets within a volume group must have unique data set names. If not, your job can abend. When a data set is extended to multiple volumes, Mass Storage Volume Control functions cannot determine that the volume being chosen does not already contain a data set with the same name as the one to be extended. When such a condition does occur, End-of-Volume abends the job for the data set being extended, which is the same as with real volumes on real DASD.

What New Responsibilities Are Introduced?

With the decision to add a Mass Storage System to your present computing system come new responsibilities. I call the individual who handles these responsibilities the space manager. The space manager's job is a combination of the jobs of the librarian of present tape or DASD systems and more. As soon as the decision is made to add a Mass Storage System to your present system, the space manager's job should be assigned. The space manager should contribute to all the planning and discussions that accompany the pre-installation and installation of the Mass Storage System. It is the knowledge and work of the space manager that makes the Mass Storage System operate at peak efficiency with a minimum amount of impact on your present operations during the installation and conversion phase of the Mass Storage System.

Your job, as the space manager, is to manage the contents of the Mass Storage Facility in terms of both the physical content and the utilization of space on data cartridges. The Access Method Services commands are your tools to manage the contents of the Mass Storage Facility. Mass Storage Volume Control functions also aid you in managing the physical content of the Mass Storage Facility and the space on data cartridges. Mass Storage Volume Control functions are aimed at solving the problems involved with managing the large number of mass storage volumes in the Mass Storage Facility. Mass Storage Volume Control functions provide features to assist a tape oriented computing system user to operate in a DASD environment. The support allows a DASD user to continue his current operations with no major change.

Creating and Maintaining the MSVC Data Sets

Another of your jobs, as the space manager, is the responsibility for the creation and maintenance of the Mass Storage Volume Control data sets as well as the management of the volumes described in the data sets. The functions of data set creation and maintenance, require special support to ensure that the Mass Storage Volume Control functions perform efficiently and consistently.

Creating the Mass Storage Volume Control Data Sets

Your first requirement is the creation of the Mass Storage Volume Control data sets, the Inventory (usercat.MSVI) and the Journal (usercat.MSVCJRNL) data sets. These data sets must be allocated prior to the first Mass Storage System Initial Program Load after system generation. Although these data sets can reside on either real volumes or mass storage volumes, they should be allocated on low-use, real, private volumes. Such an assignment enhances Mass Storage Volume Control functions performance by reducing data set contention problems, as well as simplifying Inventory data set backup and restore procedures.

During the initial Mass Storage System activity, when you are executing a high number of commands to define groups and volumes, you should take frequent backup copies of the Inventory data set to prevent loss of data due to exceeding the Journal data set threshold. The Mass Storage Volume Control functions backup procedure is described in the section "What Are the System Operator Job Changes?". You have another requirement during the initial Mass Storage System activity and that is the compression of the usercat.MSVI data set. This function is particularly important during times when volumes are being created at a high rate because volume records are being added to the Inventory data set in a random order. The random order of volume creation can cause performance degradation due to excessive VSAM control interval splitting, which results in inefficient record indexing and space utilization. To prevent such a situation, you should run the Access Method Services REPRO command against the usercat.MSVI data set and compress it.

Maintaining the Mass Storage Volume Control Data Sets

Once the Inventory data set has become stable, the need to perform back-up operations on it is lessened. To expedite data set recovery, however, you should establish a back-up procedure to be executed regularly. The time intervals at which this procedure is executed depends on the estimated number of Access Method Services commands to be used and the number of space manager messages anticipated in the Mass Storage System. You should also establish a regular procedure for printing your messages because these messages provide a record of the Inventory data set status.

Defining and Maintaining Mass Storage Volume Groups

Volume use for the Mass Storage System is primarily the same as it is for real drives (DASD) today. STORAGE, PUBLIC, and PRIVATE use for both specific and non-specific requests has not changed. However, an additional feature, volume groups, has been added to aid in converting applications from tape to the Mass Storage System that makes use of volumes as PRIVATE. This is compatible to tape volume use and should cause no concern.

Defining Mass Storage Volume Groups

Mass Storage Volume Control's volume grouping feature is primarily directed to the tape user. The primary purpose of the grouping feature is to cause a general-use mass storage volume to be mounted for a non-specific request for a new data set. Another purpose of the grouping feature allows you, the space manager, to better manage the many mass storage volumes in the Mass Storage Facility. You can establish groups that are unique due to the characteristics of the data in them. Also you may want some special groups for such things as sensitive data or multi-volume data sets. However, you have to determine this from the operation of your system.

By having groups, space fragmentation problems can be avoided or minimized for the groups for tape users by requiring that all users of the tape group use the space default provided by the group. If the DASD user is permitted to use his space-overrides on the groups for tape users, fragmentation problems can result. Also, you can better maintain the groups by knowing how they are being used, tape or DASD. Your major effort is going to be on the groups for tape users, because the DASD users know more about DASD space management, and require less of your time.

Your support revolves around two major concepts: (1) the ability to group a number of mass storage volumes with like characteristics under one name (subset the total mass storage volumes into manageable units), and (2) the collection of data about the mass storage volumes and groups in one central data set for control and ease of access and reporting.

It is your responsibility to define the groupings of the mass storage volumes for the users of the Mass Storage System. The groupings can be made on the basis of the objectives of your installation (such as performance, space utilization, application area, and run characteristic types such as batch, Time Sharing Option, and others). For example, the groups can be assigned by application area (inventory, payroll, billing, and others) and data set size within the application areas. Using System Management Facilities (SMF) data, you analyze your present data set sizes, allowing for growth factors, and assign data set default sizes to the groups within the particular application areas. This grouping by uniform size within the mass storage volumes assigned to the application area leads to reduced space fragmentation problems and keeps data sets associated with the application (for mass storage volume management) on a known number of mass storage volumes. You have the responsibility of managing the groups. You must assign mass storage volumes to the group before new data sets are created.

You have the responsibility for managing the mass storage volumes. You use the reports available from the Inventory data set to find groups and mass storage volumes that have potential space problems, run the necessary commands to resolve the problems: add new volumes to the group, remove volumes from groups, archive data sets as needed, and other functions. You should monitor the data sets allocated to the volumes to see if the space allocations were properly assigned to the groups. You can change the space values assigned to the groups without affecting the user's job control language to meet the changing needs of the Mass Storage System and the CPU or CPUs. The summary space information in the Inventory data set allows you to locate volumes that have space problems. To find detailed information on the data set allocations within a volume, you must access the Volume Table of Contents through the use of operating system utilities.

You have the ability to prevent or disallow allocations on specific volumes within the groups if you make the volumes inactive for a period of time.

Mass Storage Volume Group Maintenance

You control the volumes belonging to a group. The Access Method Services commands and the user of the volumes can aid you in this task. The MODIFYV command allows you to move volumes from group to group, group to no group, and no group to a group. When using the MODIFYV command, you can prevent group management problems such as data sets extending needlessly over multiple volumes. If you have a need to move a volume to a group or to ungroup it, you should run utilities to verify what other volumes you should move. For non-VSAM catalogs and data sets, the IEHLIST utility is executed to:

- List the Volume Table of Contents to determine which data sets are on a mass storage volume (LISTVTOC).
- List the catalog of the data set(s) to determine other volumes containing the data set (LISTCTLG). If you are not using catalog facilities, you are dependent on the user to provide you with this information.

If a volume contains VSAM data sets, the Access Method Services LISTCAT command should be executed also to identify multi-volumes of the VSAM data sets.

There is a case when the Mass Storage System will cause a data set that is on ungrouped volumes to extend to a volume in SYSGROUP. When End-Of-Volume requests a volume to extend a data set that is currently on ungrouped volumes, Mass Storage Volume Control functions select a volume from SYSGROUP, the system default group. You and the user can decide if corrective procedures are required for this data set.

You can establish rules for using volumes that are in a group. Your control of the volumes can be aided by using the Access Method Services commands and the Operating System (OS/VS) utilities.

Mass Storage Volume Group and Mass Storage Volume Reports

You can use the LISTMSVI command to get management information about groups and volumes. The information for the report is obtained from the new system data set, usercat.MSVI.

You must be aware that the reported SPACE information on the LISTMSVI report is sometimes down-level. This situation could exist for the following reasons:

- A volume was mounted at the time the report was run.
- A Mass Storage Control purge type of operation has been executed.
- Mass Storage Volume Control functions have been disabled by the system operator. This state of operation allows the Mass Storage System to continue operating but group selection is not provided, space information is not updated for volumes when they are demounted, and the Inventory data set is not updated.
- Space information maintained by Mass Storage Volume Control functions for "permanently resident or reserved" volumes (Storage or Public or Private) is down level. Mass Storage Volume Control functions update volume space information when a volume is demounted. Therefore, space information for permanently resident volumes is always down level. For reserved volumes, space information is down level except when the system operator issues an UNLOAD command for the volume.

  To obtain the current SPACE information, you can use the LISTVTOC command.

Creating or Modifying Mass Storage Volumes

The job of creating or modifying mass storage volumes is similar to today's function of assigning a pack to a user and preparing it for his use. The CREATEV command allows you to create mass storage volumes. In addition to writing the standard volume label and formatting the Volume Table of Contents, the command allows you to specify some unique volume characteristics. You must create the groups and assign the volumes, when you have created them, to the appropriate group. Optionally, you can select specific data cartridges by serial number to compose the volume, or by default, the Mass Storage Control selects two data cartridges from the Scratch Cartridge List. During creation of the volume, information about it is placed in the Inventory data set. After successful creation, the volume is eligible for all activities against mass storage volumes. If you must modify previously created volumes, the MODIFYV command is used. The SCRATCHV command returns the data cartridges of a no longer needed volume to scratch data cartridges.

Converting Data

As the space manager, you are responsible for moving data into and out of the Mass Storage Facility. In a computing system where data currently exists on real 3330 Model 1 Disk Storage, the CONVERTV command mass transfers that data to a mass storage volume in a one for one image. The transfer of data is accomplished without CPU activity. Since all VSAM data sets must be recataloged to reflect the new device type, the VSAM catalog is updated for the converted data set. To relieve you of recataloging each non-VSAM data set individually, the CONVERTV command optionally updates non-VSAM data sets. The CONVERTV command transfers data from a 3336 Model 1 Disk Pack to a mass storage volume or from a mass storage volume to 3336 Model 1 Disk Pack. For other types of volumes such as tapes and 2314 DASD, the ability to convert data without CPU involvement is not possible. In this case, data must be converted to and from the Mass Storage System by means of standard data set commands. If data integrity is to be maintained, you must be fully aware of the type of data and its characteristics as it is moved in and out of the Mass Storage Facility.

ISAM data sets that are being placed on mass storage volumes should be converted to VSAM and use the compatibility interface (no program change) of VSAM. If ISAM data sets are not converted, access is limited to "cylinder fault" mode.

Transporting Data

Although the data cartridges are not intended to be used as interchange media, occasions will arise when temporary or permanent movement of data between Mass Storage Systems is required. The ADDV command must be executed to move specific volumes from the Transient Volume List to the Volume Inventory table. The STOREV command marks the specified volumes in the Volume Inventory Table and the Inventory data set as inactive and places the volume in the Transient Volume List. You should note that while data cartridges are outside the Mass Storage System, the means of identification is the data cartridge serial number, which is physically printed on the tape of the data cartridge. The relationships of the data cartridge serial numbers to volumes is available through the listings produced while the data cartridges were resident in the Mass Storage System, and through the information contained in the Inventory data set.

Determining Mass Storage System Status

Considering the magnitude of the space available in the Mass Storage System, you must have the ability to determine the contents and status of the information in the Mass Storage Facility. Several reports are available to assist you.

A Tape Cartridge Statistics report is available through the Mass Storage System Data Analyzer (SDA) problem program. This report uses SYS1.LOGREC information to provide volume error statistics on the volumes that are stored in the Mass Storage Facility.

Reports produced by the LISTMSVI command are available from the Inventory data set, which contains information at a volume and group level, including a summary of space information for each volume defined in the Mass Storage System. For determining detail space utilization at a volume level, OS/VS utilities (LISTCAT and IEHLIST) must be used.

For determining utilization at the Mass Storage Facility level, a command, LISTMSF, provides a listing of:

- Active mass storage volumes
- Scratch data cartridges
- Transient (inactive) volumes

A summary report is available through LISTMSF and indicates the number of volumes and/or data cartridges and the number of empty cells.

To assist you in managing occupied space and reclaiming inactive space, the LISTCAT command produces a report based on the VSAM catalog that provides:

- A listing of data sets that have expired or will expire in "N" days, where you supply the value of "N".
- A list of data sets that are "N" or more days old. Here again, you supply the value of "N".

Since this report is dependent on the VSAM catalog, it is obviously not applicable to a non-VSAM environment but is available for non-VSAM data sets. Operating system utilities continue to be available for data that is controlled by a non-VSAM catalog and access method.

Recovery

The recovery of data in the Mass Storage System is a joint effort between you and the system operator. Some of the things you have to consider for recovery are mentioned in this section but you should also read the section "Data Set Recovery" under the system operator job description for additional recovery considerations.

Backup

A semi-automatic, optional backup feature for volumes is provided. You may specify the number of backup copies to be retained for a volume. The COPYV command can then be used to provide a backup copy of the volume. It will automatically retain the specified number of copies. The RECOVERV command can be used to restore a volume from a backup copy.

Archive Control

There are two levels of archive control:

- To collect data sets to be archived and put them on a pre-defined archive volume.
- To make the mass storage volumes inaccessible (for example make the volume inactive) within the cartridge store and optionally move the volume to shelf storage. This is accomplished through new Access Method Services commands.

Note that there is no new Mass Storage System support to control or automatically recover archived data. You should control or recover through manual operations. You should catalog the data sets as you put them on the archive volume and use the description field of the STOREV command to describe the volume as an archive volume or describe the location of the volume if it is to be stored outside the cartridge store. When you need the data sets that are on the archived volume, you can use the ADDV command to activate the volume. If the volume is stored outside the cartridge store, you can enter the volume through the cartridge access station and then activate the volume.

Mass Storage Volume Control Recovery

A procedure to perform data set recovery is provided so that you can restore the Inventory data set to a totally operable condition.

Data set recovery is performed through a series of Mass Storage Volume Control functions, Access Method Services, and system utilities selected and executed by you and your computing system. Their purpose is to restore the Mass Storage Volume Control data sets to a full function level for volume access. A description of the Mass Storage Volume Control functions that are used in data set recovery is contained in the section "Mass Storage Volume Control Recovery and Maintenance Functions".

If, during the course of I/O processing, the Inventory or Journal data sets are determined to be totally inaccessible, the following actions are taken:

- If a physical I/O error is encountered during access to the Inventory data set, the operator is notified, and you will receive a message. The job may or may not fail depending upon the type of request. When to recover the Inventory and Journal data sets must be a decision based on job failures due to I/O errors to the Inventory and Journal data sets.
- If the Journal data set is inaccessible or full, you and the operator are notified. During operations that are normally journaled, you and the operator are either notified of the loss of Journal data set recording or else the jobs will fail or both depending on the type of job.

Glossary

The following terms are used throughout this book.

accessor: The component in the Mass Storage Facility that transports cartridges between the cells, the data recording devices, and the cartridge access station.

accessor control: The component in the Mass Storage Facility that decodes and sequences messages from the Mass Storage Control and directs the motion of the accessor.

acquire: To allocate space on a staging drive and to stage data from a cartridge to the staging drive.

active mass storage volume: See active volume.

active volume: A mass storage volume residing within the Mass Storage Facility and available for mounting by the operating system.

attention interrupt: A signal from the Mass Storage Control to the CPU that a message is waiting for the CPU.

base mass storage volume: See base volume.

base volume: A mass storage volume that can have copies or duplicates.

BIND: (1) An attribute of a data set that keeps the data set on one or more staging drives until the data set is released by the user regardless of the length of time or the demands for space. (2) An attribute of a mass storage volume that reserves an entire staging pack for the mass storage volume whenever the volume is mounted.

cartridge: The storage medium of the Mass Storage System, consisting of a container with magnetic media wound around a spool inside it. All cartridges within the Mass Storage Facility are online.

Cartridge Access Station: An opening on the Mass Storage Facility where cartridges are manually loaded or ejected.

cartridge label: An area on the magnetic storage media that contains the cartridge identification and other information about the cartridge.

cartridge serial number: A unique number that identifies a cartridge; recorded magnetically and visibly on the media.

Cartridge Store: The part of the Mass Storage Facility that consists of the cells, the accessors, and the accessor controls.

cell: A hexagonal compartment within the Mass Storage Facility where a cartridge is stored.

cell cube: A block of 32 cells, four X addresses by four Y addresses, by two Z addresses.

convertible drive: A drive that can be designated to be either a staging drive or a real drive.

copy mass storage volume: See copy volume.

copy volume: An inactive mass storage volume that is an exact reproduction of another mass storage volume. Both volumes have the same volume identification.

cylinder fault: A condition that occurs when the operating system requires data that has not been staged. The cylinder fault causes a cylinder of data to be staged.

DASDERASE: An attribute of a mass storage volume that causes binary zeros to be written on the staging drive after data from the mass storage volume has been destaged.

data cartridge: See cartridge.

data recording control: The component of the Mass Storage Facility that starts and stops data recording devices, encodes and decodes, and assists with error recovery. The abbreviation is DRC.

data recording device: The unit in the Mass Storage Facility that reads and writes data on the cartridge media. The abbreviation is DRD.

default mass storage volume group: The collection of mass storage volumes that belong to a mass storage volume group defined by the Mass Storage System Communicator. The name of the group is always SYSGROUP.

delayed response: An indication from the Mass Storage Control that a Mass Storage Control I/O is finished.

destage: To move data from a staging drive to a mass storage volume.

destage error: The result of a permanent read error when transferring data from the staging pack to the data cartridge.

DRC: See data recording control.

DRD: See data recording device.

duplicate mass storage volume: See duplicate volume.

duplicate volume: An inactive mass storage volume that has the same identification as another mass storage volume and is not a copy.

eject: To move a cartridge from the Mass Storage Facility to the cartridge access station.

EXCLUSIVE: An attribute of a mass storage volume that allows only one CPU at a time to access the mass storage volume.

Extended Group Coded Recording: The technique is used to encode the data on the media in a data cartridge. This technique includes error correction code. The abbreviation is E/GCR.

E/GCR: See Extended Group Coded Recording.

general-use mass storage volume: See general-use volume.

general-use volume: A mass storage volume that is assigned to a mass storage volume group and can be used for nonspecific requests for a mass storage volume.

group: See mass storage volume group or staging drive group.

IML: See Initial Microprogram Load.

inactive mass storage volume: See inactive volume.

inactive volume: A mass storage volume that is not available for mounting by the operating system.

Initial Microprogram Load: The action of loading a microprogram. The abbreviation is IML.

Integrated Storage Control: A feature on the Model 158 or 168 processors that control the 3330 Disk Storage. With the addition of the Staging Adapter, the Integrated Storage Control can control staging drives. See also Staging Adapter.

Inventory data set: See Mass Storage Volume Inventory data set.

Journal data set: See Mass Storage Volume Control Journal data set.

journalling: Recording transactions against a data set so that the the data set can be reconstructed by applying the transactions in the journal against a previous version of the data set.

Least Recently Used: An algorithm that determines the order in which active staged pages must be destaged. The algorithm ensures the staging drive group will always have the amount of allocatable space defined by the space manager.

loading pattern: The order in which cells are filled with cartridges that are entered in the Mass Storage Facility through the cartridge access station.

loosely-coupled: A connection of more than one CPU such that the CPUs share only channels.

Mass Storage Control: A microprogrammed portion of the Mass Storage Facility that passes information to the accessor control, and controls data and space on staging drives. The Mass Storage Control is abbreviated MSC.

Mass Storage Control Table Create: A program that builds the Mass Storage Control tables. The abbreviation is MSCTC.

Mass Storage Control tables packs: A direct access storage pack that contains Mass Storage Control tables.

Mass Storage Control twin port: A feature of a Mass Storage Control that allows the Mass Storage Control to address a total of 16 of the following: Mass Storage Facilities, 3850 Model 3 Storage Controls, or Integrated Storage Controls that have the addition of the Staging Adapter. Each Integrated Storage Control counts as two.

Mass Storage Facility: The component of a Mass Storage System that contains the storage media and the facilities for accessing the media. The abbreviation is MSF.

Mass Storage System: The name for the entire storage system, consisting of the Mass Storage Facility and all devices that are defined to the Mass Storage Control. The abbreviation is MSS.

Mass Storage System Communicator: A program that handles communication between system control programs and the Mass Storage Control. The Mass Storage Volume Control functions are an integral part of the Mass Storage System Communicator. The abbreviation is MSSC.

mass storage volume: A direct access storage volume residing on two associated cartridges.

Mass Storage Volume Control functions: A collection of functions that reside in the Mass Storage System Communicator and are designed to assist the space manager in managing mass storage volumes and mass storage volume groups. The abbreviation is MSVC.

Mass Storage Volume Control Inventory data set: Same as Mass Storage Volume Inventory data set.

Mass Storage Volume Control Journal data set: A data set that contains messages to the space manager and information used to rebuild the Mass Storage Volume Inventory data set.

mass storage volume group: A collection of mass storage volumes. The space manager can define a group, and the Mass Storage System Communicator defines a default mass storage volume group. The name of the parameter used in job control language for a group is MSVGP.

Mass Storage Volume Inventory data set: A data set that describes mass storage volumes and mass storage volume groups. The abbreviation is MSVI.

MSC: See Mass Storage Control.

MSCTC: See Mass Storage Control Table Create.

MSF: See Mass Storage Facility.

MSS: See Mass Storage System.

MSSC: See Mass Storage System Communicator.

MSVC: See Mass Storage Volume Control.

MSVI: See Mass Storage Volume Inventory data set.

nonstaging drive: Same as real drive.

page: The unit of space that is allocated on a staging drive. The page consists of 8 cylinders.

path: A hardware connection known to the operating system that permits the movement of data within the hardware.

placeholder record: A temporary base or copy volume record that the Mass Storage Volume Control functions create and add to the Inventory data set during the operation of some of the Mass Storage System Access Method Services commands.

primary CPU: The CPU in a multi-CPU system configuration that has the responsibility of processing unsolicited messages from the Mass Storage Control.

real drive: A drive that is attached to a storage control (3830 Model 3) or an Integrated Storage Control with a Staging Adapter and has the pack formatted as a nonstaging (or real) pack. No staging is performed on this drive.

relinquish: To free space on a staging drive. It can cause data to be destaged.

restricted-use mass storage volume: See restricted-use volume.

restricted-use volume: A mass storage volume assigned to a mass storage volume group and used only by requests specifying the mass storage volume identification.

scratch: To remove the information about a mass storage volume from the Mass Storage Volume Inventory data set and put the identification of both cartridges on a list of scratch cartridges.

scratch cartridge: A cartridge that is not part of a mass storage volume.

scratch data cartridge: See scratch cartridge.

SHARED: An attribute of a mass storage volume that allows more than one CPU at a time to access the mass storage volume.

solicited message: A message from the Mass Storage Control to the CPU that is expected by the CPU.

space manager: The person who is responsible for managing space on mass storage volumes.

stage: To move data from a cartridge to a staging drive.

stage error: The result of a permanent read error while trying to read a particular stripe of a data cartridge.

Staging Adapter: (1) An addition to a System/370 Model 158 or 168 Intergrated Storage Control (ISC) feature that enables the ISC to operate in a Mass Storage System. (2) A 3830 Model 2 Storage Control that has been modified to operate in a Mass Storage System. The modification changes the designation of the storage control to a 3830 Model 3 Storage Control.

staging drive: A 3330 Model 1, 2, or 11 that is designated by the Mass Storage Control Table Create program to receive data from a Mass Storage Facility.

staging drive group: A collection of staging drives for space management and recovery. It is created by the user with the Mass Storage Control Table Create program.

staging effective data rate: An amount of data transferred between the data recording devices and the staging drives in one second. The amount of data is normally averaged over an hour.

staging pack: A 3336 Disk Pack that has been initialized to receive data from a Mass Storage Facility.

Storage Control: The 3830 Model 3, the direct access storage device control unit in the Mass Storage System that controls the transfer of data during staging and destaging operations. Also see Staging Adapter.

stripe: The portion of the cartridge media that is accessible to a given head position.

subsystem identification: An identification on each device in the Mass Storage System. The devices include staging adapters, staging drives, Mass Storage Facility, data recording devices, and data recording controls. The abbreviation is SSID.

System Data Analyzer: A program that analyzes collected data about hardware errors in the Mass Storage System.

system effective data rate: An amount of data transferred between the staging drives and the CPU in one second. The amount of data is normally averaged over an hour.

tables pack: See Mass Storage Control tables pack.

tightly-coupled: A connection of more than one CPU such that the CPUs share main storage and communicate directly with one another.

trace: A monitor in the Mass Storage Control that records data about Mass Storage System activity and staging and destaging. The data describes completed Mass Storage System functions from the activity schedule queues plus time stamps.

twin port: See Mass Storage Control twin port.

unsolicited message: A message from the Mass Storage Control to the primary CPU that is not requested or expected by the primary CPU.

virtual drive: A direct access storage device that does not physically exist. It exists logically on one or more staging drives.

virtual unit address: An address for a virtual drive that consists of the channel address, the Staging Adapter address and the device address. The virtual unit address can be assigned to any staging drive group. Each staging drive can have more than one virtual unit address, but only one real unit address.

virtual unit control block: A unit control block that contains a virtual unit address.

virtual volume: The data from a mass storage volume while it is located on a staging drive.

volume: See mass storage volume or virtual volume.

volume group: See mass storage volume group or default mass storage volume group.

WRITEINHIBIT: An attribute of a mass storage volume that prevents writing on the mass storage volume. It means the same as read-only.

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